PRICE ADJUSTMENT AND MARKET STRUCTURE

by

Simon I. Domberger

thesis submitted for the degree of

Doctor of Philosophy

to the

UNIVERSITY OF WARWICK

Department of Economics

December 1977

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

Foremost acknowledgement is due to Professor Keith Cowling who supervised this research and who provided continued guidance and unfailing encouragement at all stages of the work. I am also very heavily indebted to Dr. Paul Stoneman for devoting considerable time to many useful discussions and suggestions. To Dr. John Cubbin, Professor Avinash Dixit, and Mr. Norman Ireland, I am grateful for their helpful comments.

My debt also extends to those colleagues, too numerous to mention here, of the Department of Economics and the Centre for Industrial Economic and Business Research at the University of Warwick, with whom I discussed various aspects of this work.

The research was carried out as part of a larger project entitled "The Economic Effects of Mergers" under the auspices of the Office of Fair Trading. My gratitude is extended to them for providing the financial support which made this work possible.

A considerable body of data required for the research was previously either unavailable or subject to disclosure restrictions. I am grateful to the Economics and Statistics Division of the Department of Industry for supplying the necessary data and for co-operating in the construction of the missing series.

The acknowledgements would not be complete without thanking Clive Hicks, Valerie Jephcott and Mark Partridge for valuable assistance with the data processing; my wife Brenda for painstaking checking of the text and equations; and Maureen Garcia for the excellent typing of the manuscript. I alone am responsible for all remaining errors and omissions.

LIST OF FIGURES AND TABLES

Figures

Tables

Appendix Tables

ABSTRACT

The present thesis is concerned with the relationship between price adjustments in response to changes in economic conditions and industrial market structure. Its point of departure consists of abandoning the time-honoured assumption that firms in industrial markets act as if they were price takers. Instead, attention is focused on the determinants of price adjustment in a more realistic industrial setting.

Following the introductory analysis, a synthesis is proposed between the long-standing "administered prices" hypothesis, and the recent theories associated with the "new view" of Keynes. It is suggested that both approaches have common theoretical underpinnings which are themselves closely related to this thesis.

The main body of analysis consists of a theoretical and an empirical investigation. In the theoretical section, two distinct aspects of the price adjustment decision are examined. The first concerns the comparative statics of adjustment and involves an analysis of the factors which determine the magnitude of price adjustments following changes in cost and demand. Moreover, the influence of market structure on the adjustment process is examined through its impact on the costs of search which are associated with the pricing decision. The second, and no less important aspect of the theoretical investigation concerns the dynamics of price adjustment. The object of this analysis is to assess the impact of market structure on the rate of price adjustment over time.

The two hypotheses developed in the theoretical section are put to extensive empirical testing. The quantitative analysis involves mainly time-series and cross-section regressions, but other statistical techniques such as rank correlation and covariance tests are also employed.

The first of these hypotheses is that price adjustments in response to short-run changes in demand could be attenuated relative to those

occasioned by changes in marginal costs. The rationale for this asymmetry is based on the unequal impact of search costs. The empirical findings, whilst by no means conclusive, do not contradict this view.

The second hypothesis suggests that a high degree of industrial concentration will be associated with high rates of price adjustment. This is because concentration facilitates the process of dynamic co-ordination amongst firms by reducing the costs of search. The empirical results come out strongly in favour of this hypothesis. The consequential implications regarding "administered prices" and the management of inflation are explored in the concluding chapter of this thesis.

Chapter 1

INTRODUCTION

1.1 The Origins of the Thesis

This thesis lies within the field of industrial economics, yet it owes its origin to the fundamental question concerning the process of adjustment from disequilibrium. This question, which pervades the cognate areas of inflation and general equilibrium theory, remains an unsettled issue both in the theoretical and empirical literature. The analysis of price and quantity adjustment generally depends on which conceptual framework is adopted, that is, on whether the analytical foundations are based on the Keynesian macro-system or the neo-classical theory of general equilibrium.

This thesis originated as an attempt to examine closely the specific influence of structural and behavioural characteristics of the market on the adjustment process. However, before outlining its objectives we shall elucidate the analytical approaches mentioned above, and examine their relationship to the present thesis.

The majority of the current elementary macroeconomic texts analyse the behaviour of economic aggregates in terms of the simplified Keynesian model. It is generally assumed that aggregate supply is infinitely elastic at current prices up to the point of full employment of resources. Aggregate output is a function of the level of income in this model, and the level of income is directly influenced by aggregate effective demand through the familiar multiplier process. If the level of income is in excess of that which is consistent with full employment, the result would be the emergence of an "inflationary gap"; output would not increase any further and instead the price level would begin to rise. Thus up to the full employment level of output the economy would respond to disequilibrium through adjustment in aggregate supply - i.e. quantity adjustments.

This, briefly, is the conventional paradigm of macroeconomic behaviour, cast in the Keynesian tradition. By contrast, the neo-classical theory of general equilibrium, which purports to explain the interaction of all markets in the economy and thus relates to macroeconomics per se, presents a very different picture. In this model changes in demand or the emergence of excess demand in any market is followed by an instantaneous adjustment of price which restores equilibrium in the market. Furthermore, this system precludes any resource unemployment since excess supply is incompatible with the concept of Say's Law and the flexibility of prices.

Thus, the fundamental dichotomy of economic behaviour presented by the two contrasting approaches discussed above is rather perplexing. The Keynesian model of income determination emphasises the role of output adjustments, whilst the general equilibrium schema is couched in terms of competitive price adjustments. Hence, the nub of this paradox would seem to be whether price or quantity adjustments provide the essential mechanism through which equilibrium is restored, and this issue continues to be the subject of debate in the literature. This is illustrated by the fact that even the recent developments concerning the integration of value and monetary theory have not shed much light on this problem, as exemplified by Friedman's policy oriented restatement of the quantity theory of money:

> "It [the equation relating income, Y, to the quantity of money, M] then says that changes in money income mirror changes in the nominal quantity of money, but it tells nothing about how much of any change in Y is reflected in real output and how much in prices".(1)

---

(1) Friedman (1956), p.15.

The problem of decision making facing the firm when the market is in disequilibrium had been largely sidestepped until Arrow first looked at this issue in 1959. His seminal contribution, entitled "Toward a Theory of Price Adjustment", began with the following statement:

> " . . . there exists a logical gap in the usual formulation of the theory of the perfectly competitive economy, namely, that there is no place for a rational decision with respect to prices as there is with respect to quantities".(1)

Arrow specifically considered two related problems associated with market disequilibrium. The first concerned the lack of information relating to the true state of demand, whilst the second and no less important question concerned the lack of information about how other firms are responding to disequilibrium. However, the detailed discussion of Arrow's analysis will be deferred to a subsequent chapter.

It is interesting to note that the contemporary debate on the reappraisal of Keynesian economics is concerned with the closely related question of the influence of adjustment problems at the firm level on aggregate economic activity. Not surprisingly, therefore, much of the analysis represents a logical extension of Arrow's pioneering contribution, a fact which is amply reflected in the following statement by one of the principal contributors to the debate:

---

(1) Arrow, in Abramovitz et al. (1959), p. 41.

> "The main innovation - and virtually the only major innovation - attempted in the General Theory was the effort to provide a 'systematic' analysis of the behaviour of a system that reacts to disturbances through quantity adjustments rather than through price-level or wage rate adjustments".(1)

In the next chapter the common theme between this thesis and certain issues associated with the "new view" of Keynes will be looked at more closely. We shall also examine the link between the present thesis and the celebrated "administered prices" hypothesis, although a critical appraisal of the hypothesis will be postponed until the review of empirical studies on the behaviour of industrial prices.

We would therefore emphasise that this thesis is rooted in the somewhat varied strands of theory and empirical evidence concerned with the subject of price flexibility. The growing body of literature, which is often contradictory in character and which has generated a perennial debate, highlights the fact that the price adjustment decision in a modern industrial environment is a complex question which is open to more than one analytical approach. The line of thought which will be adopted in this thesis is based on the premise that the institutional environment, as manifested in market structure, bears an important influence on price adjustments in response to disequilibrium.

It should also be stressed that although there exists a substantial body of empirical work in this area, most of it is highly aggregative and relates to United States data. There is therefore a pressing need for disaggregated empirical work which relates specifically to the United Kingdom economy.

---

(1) Leijonhufvud (1968), p. 24.

1.2 The Objectives of the Thesis

The objective of this thesis, briefly stated, is to examine the role played by industrial structure in the price adjustment process. Our aim is to analyse its influence both on the absolute magnitude of price adjustment and on its rate of change over time.

There is currently no general agreement among economists regarding the impact of market structure on the movement of prices. Perhaps the most widely accepted view on this subject is that of Stigler, which is summarised in the following statement:

> "The traditional economic theory argues that oligopoly and monopoly prices have no special relevance to inflation.[1]

Nevertheless, some economists have recently suggested that the present inflation is the symptom of a deep-seated struggle between competing socio-economic groups who are attempting to shift the distribution of income in their favour. Those who argue along these lines see market structure, and in particular the trend toward increasing concentration in product and factor markets, as an important influence in this process.[2]

On the same theme, but focusing on the product market, Cowling and Waterson (1976) found that increases in the level of concentration were associated with significant increases in industrial price-cost margins. If such increases take place over a relatively short time period, and if wage rate adjustments follow quickly as employees hasten to restore real incomes to their former levels, the resulting process of inflation would thus be complete.

---

(1) Stigler (1962), p. 8.

(2) For interesting expositions of this view see Wiles (1973) and Panić (1976).

A price adjustment is defined as the change involved in moving from one equilibrium price to another over an arbitrarily specified period of time. But it should be stressed that we shall not be concerned with the fundamental causes of inflation per se, that is, with the recurrent sources of disequilibrium which lead to price changes. The aim will be to examine the factors which influence the price adjustment process in response to an exogenous disturbance, and in particular, to analyse the way in which market structure may affect the adjustment decision.

Our basic assumption will be that firms attempt to maximise profits and, in addition, that they recognise the benefits to be derived from joint profit maximisation. We shall also assume that this recognition does not depend on whether industrial structure is characterised by a tightly knit oligopolistic group or by a large number of firms. However, what stands in the way of collective profit maximisation and the co-ordination of price and output policies which it necessitates, is the problem of information and the associated costs of obtaining it, in short, the problem of search costs. Not until Stigler's contribution concerning the economics of information was this problem explicitly recognised and given proper attention in the literature. Before then it had generally been accepted that, assuming the effective operation of markets in the economy, the problem of information was unambiguously solved by virtue of the parametric function of prices.

Yet once the assumption about the perfect functioning of markets which was criticised by Arrow is relinquished, the problem of information becomes an important and integral aspect of the decision making process associated with price adjustment. For the crucial feature of a non-Walrasian market setting is that firms are no longer price takers; they must adjust prices individually but not without due consideration of the potential reactions of their competitors. Therefore in this setting the costs of search may have a crucial influence on the adjustment process.

Thus, an important objective of the thesis will be to integrate search activity into the price adjustment decision. We shall give particular attention to the question of differences in the impact of search on price adjustments to changes in cost and demand. Furthermore, the postulated relationship between the costs of search and industrial market structure will be seen to have a central role in our thesis. The analysis of price adjustment will be both theoretical and empirical, and the hypotheses which will be derived from the theoretical models will be put to extensive empirical testing. The findings will then be evaluated and compared with those of other researchers.

An additional but incidental objective will be to put forward a synthesis of the recent theoretical controversy associated with the "new view" of Keynes and the empirically based "administered prices" hypothesis.

1.3 Outline of the Research

Following this introduction, chapter 2 will contain a broadly based discussion of the determinants of price adjustment. Its purpose will be to consider all the factors which are of relevance to the price adjustment decision as a first step toward the subsequent formalising in the theoretical analysis. In this chapter we shall consider in some detail the theoretical and empirical controversies which have been referred to in the preceding section.

Chapter 3 will consist of a review of the literature on the subject of price adjustment. The chapter will be divided into two main sections, the first dealing with the literature on price adjustment *per se*, and the second with the question of risk and uncertainty.

In chapter 4 we shall present the theoretical analysis of price adjustment. This will consist of essentially two price adjustment models. The first will be concerned with the comparative statics of adjustment, that is, with the magnitude of the price change which will restore equilibrium. The second model will focus on the dynamics of adjustment, i.e. on the optimal rate of price change over time.

Chapter 5 will contain a detailed discussion of methodological questions in connection with the empirical analysis. It will also include a comprehensive review of several previous empirical studies. Their methodology will be critically examined in an attempt to improve the statistical reliability of our tests. The chapter will be concluded with a detailed description of the data and, where appropriate, the methods used in constructing additional series from primary sources.

In chapter 6 we shall report the empirical findings. These will involve mainly the estimation of industry price adjustment equations, but other statistical tests will also be included.

The final chapter of this thesis will contain three sections. The first will be concerned with an overall appraisal of the theoretical analysis and the empirical results. In the second, the policy implications of these results will be discussed. Finally in the third section we shall suggest some directions in which this research may be usefully extended.

Chapter 2

THE DETERMINANTS OF PRICE ADJUSTMENT

2.1. Introduction

In this chapter we shall draw together the main strands of the theoretical and empirical analysis which will be developed in subsequent chapters. The purpose of the discussion is to examine the price adjustment decision in the widest possible context, including the theoretical underpinnings of Walras (1874) and Marshall (1920). We shall also explore the short-run alternatives to price adjustment which exist in a modern industrial setting, namely the strategies of advertising and quality change.

With these thoughts in mind, we shall also suggest that the present thesis is closely related to two important controversies in the theoretical and empirical literature. Both are concerned with the behaviour of prices in the modern industrial economy and thus with issues which are fundamental to this thesis.

2.2. The Theoretical Controversy

This controversy concerns a suggested re-interpretation of the Keynesian contribution to economic analysis. The protagonists of this debate are Clower (1965), Leijonhufvud (1968), and Hines (1971), but there are other participants. The essence of the controversy is the suggestion made by the above-mentioned authors that Keynes' General Theory has been narrowly interpreted by mainstream economists since its appearance in 1936. The conventional interpretation of the General Theory is, briefly, that government participation in the management of a market economy is both necessary and desirable because, left to itself, the economy will not gravitate towards a full-employment equilibrium position as the neo-classical theorists suggested it would do. In terms of the modern paradigm, the equilibrium level of income is determined by the equality of aggregate planned expenditure and aggregate realised spending. Since these can be equal at less than full-employment, the equilibrium level of income is consistent with unemployed resources, and furthermore, there are no automatic forces which would restore full-employment in the economy. Consequently the government has the important role of managing aggregate effective demand to ensure full-employment.

This synthesis of the textbook approach to Keynesian economics is necessarily oversimplified, but is sufficient to illustrate the gulf which exists between this income-expenditure approach, as it has come to be known, and the "new view" adopted by its critics. They suggest that the Keynesian contribution has a far greater theoretical significance. They claim, essentially, that the General Theory constituted an attack on the neo-classical theory of market behaviour with important implications for the macro-economy. This attack is based on the notion that the orthodox theory of exchange assumes an institutional environment within which the information required for optimisation by decision-makers is readily available. More specifically, in markets which have an exchange clearing system, known in the theoretical literature as the "Walrasian auctioneer", firms do not adjust prices individually. They respond, instead, with a quantity adjustment to a price change which is determined in the market. In such a system prices are parametric; they provide the necessary information with which the firms can make an optimum quantity decision. Leijonhufvud (1968) argued, however, that the neo-classical assumptions as laid down by Marshall (1920) were fundamentally misleading. This is because the assumption that price adjustment velocities were infinite by virtue of the exchange clearing mechanism, and that consequently it was quantity supplied which displayed a slower rate of adjustment, could only be sustained in rather special circumstances. Thus, in markets with different institutional arrangements, that is, with no auctioneer and where firms undertake their own price adjustments, this ranking of velocities no longer holds:

> "In the Keynesian macro system the Marshallian ranking of price and quantity adjustment speeds is reversed".(1)

Thus, in terms of the "new view" of Keynes the emergence of unemployed resources is caused by quantity adjustments which occur more rapidly than price adjustments. The ranking of velocities is reversed because of the problems associated with optimal adjustment in a limited information market environment. Although the exposition of the reinterpretation of Keynesian economics is grossly oversimplified, the nexus between this thesis and the "new view" should now be clear. But although the present thesis is also concerned with the problem of price adjustment, it places greater emphasis on the role of industrial structure in the adjustment process. Before going any further with this discussion however, we shall briefly review the empirical controversy mentioned above.

2.3 The Administered Prices Controversy

The administered prices hypothesis was first promulgated by Means (1935) as an explanation of price rigidities in times of recession. More recently, Means (1959, 1972) has reiterated his position and has found growing support among economists, most notably from Galbraith (1957) and Ackley (1959). According to the hypothesis, the pricing behaviour of firms in industrial markets does not conform to the traditional pattern dictated by supply and demand. Furthermore, the scope of the hypothesis has been widened recently by Means (1972) who suggested that the post second World-War phenomenon of simultaneous recession and inflation is caused by price administration.

An administered price is defined as:

> " ... a price set for a period of time and a series of transactions".(2)

It is clear, therefore, that the hypothesis is concerned with pricing behaviour over time. It purports to explain the way in which industrial prices are adjusted to changes in economic conditions, and consequently it falls within the gamut of the present thesis.

---

(1) Leijonhufvud (1968), p. 52.

(2) Means (1972), p. 292.

The important feature which is stressed by Means is the rigidity of industrial prices relative to market dominated prices. The concept of rigidity is carried one step further, to suggest that administered prices actually move countercyclically - rising in recessions and falling in periods of expansion. Thus, the theory purports to explain the emergence of simultaneous recession and inflation. However, the administered prices thesis has been hotly debated since it first appeared in 1935. Claims and counter claims have been put forward but the evidence remains inconclusive and the theoretical underpinnings are not convincing. The debate has also been confounded by different interpretations of price flexibility.

The main problem with the administered prices hypothesis is that it suffers from a lack of theoretical precision. This manifests itself in two ways: first, the definition of market dominated prices is not made explicit. Are these prices set in low concentration industrial markets or in perfect markets of the traditional kind, i.e. commodity and stock markets? Second, no attempt is made to distinguish between administered price adjustments to changes in cost and demand. The distinction is important for without it an assessment of price inflexibility relative to what it would have been in traditional markets cannot be made. For example, in an upswing, not all industries experience the same degree of cost increases. If no allowance is made for these differences our observations on price movements across industries will not be comparable. For proper comparison the exogenous conditions behind price movements must be standardised.

It is evident that the administered prices thesis has concentrated on the empirical evidence without attempting to relate the phenomenon of price inflexibility to the specific market environment within which it takes place. A recent attempt in this direction by Gordon and Hynes (1970) did not, however, go very far in this direction.

The important question which must now be asked is: how are these two controversies related and what is their special relevance to the present thesis? The answer to the first part of the question is, it will be argued, that both controversies stem from the often overlooked dichotomy between the orthodox theory of markets with its instantaneous adjustments to disequilibrium and the real institutional setting of the modern industrialised economy. As Arrow pointed out as early as 1959, a theory of price adjustment is required precisely because this dichotomy exists. The implications of this dichotomy have not yet been entirely uncovered.

Essentially, we can view the modern economy as being divided into two market types. The first is the traditional perfect market in the neo-classical sense, where buyers and sellers meet at regular trading periods, and where the price adjustment process is carried out by agents whose specific task is to clear the market. In such markets, buyers and sellers respond passively to impersonal price adjustments in which they play no part. The second type is the modern industrial "market". The term market is really inappropriate here because it conjures up the wrong model. For, in these markets, buyers and sellers do not trade collectively but do so individually through retail intermediaries. Moreover, the crucial feature of these is that firms have to make a price decision as well as a quantity decision and hence in the dynamic context they have to adjust prices whenever changes in the economic climate are in evidence. Therefore, as Arrow (1959) pointed out, one cannot blindly apply traditional market analysis to questions of price adjustment, for if we assume that each seller is a price taker, as we do in the orthodox case, then there is no one left whose responsibility it is to change prices when the market is in disequilibrium.

This distinction, if it is made, casts the process of price adjustment in an entirely different scenario. It further highlights the fact that to class low-concentration industrial markets as competitive in the traditional sense is to invite considerable analytical confusion.

2.4 A Synthesis of Theory and Empirical Evidence

From this discussion it would appear that the two controversies are themselves related to one another. As will be suggested below, at the heart of the matter lies the divergence between neo-classical market theory and the reality of modern industrial markets. Furthermore, we would contend that this dichotomy stems from one central and inappropriate assumption - namely the existence of market clearing agents such as the Walrasian auctioneer. As will be discussed in chapter 3, the recontracting or auctioneer assumption ensures _ipso facto_ that trading takes place at equilibrium prices and that adjustments to disequilibrium take place instantaneously. This dichotomy is boldly recognised by proponents of the "new view", for as Leijonhufvud (1968) states:-

> "This condition that prices be parametric - that all transactors be "price-takers" - rules out the possibility of a state in which markets do not clear at the actual price of the moment. To make analysis of adjustment processes in an atomistic market possible, this condition must be relinquished."(1)

Leijonhufvud goes on to discuss the implications of abandoning this assumption, including the resulting problems of information which may lead to short-run quantity adjustments. He also suggests that the reversal of price and quantity velocity rankings leads to a deviation-amplifying process through which the emergence of recession and unemployment

(1) Leijonhufvud (1968), p. 69.

of resources comes about.

Regarding the administered prices hypothesis, it is evident that the pricing behaviour which is being described emanates from a modern industrial environment and not from a traditional, neo-classical, market setting. Although the theoretical foundations of the hypothesis have never been made explicit by its proponents, the underlying rationale is perhaps best illustrated by the following notion which suggests that the administered prices hypothesis ".... is more fruitfully linked to the degree of uncertainty and the resulting problems of learning that face the decision maker".(1)

This problem of uncertainty and learning is essentially the same as the information problem associated with price optimisation which was emphasised by Leijonhufvud (1968) and others. Thus the common ground between these two views should now be apparent: it concerns the problem of price adjustment in a limited information industrial environment. However, the "new view" focuses primarily on the implications of sub-optimal price adjustments at the firm level on the attendant output adjustments which are amplified as a result and, in particular, on the consequences for aggregate economic activity. On the other hand, the administered prices hypothesis concentrates essentially on the apparent inflexibility of industrial prices, although the implications for large-scale fluctuations of economic activity have also been considered in this context.(2) More specifically, the proponents of the hypothesis have recognised that relative price inflexibility would lead to considerably magnified output adjustments, with serious consequences in times of recession.

---

(1) Gordon and Hynes in Phelps ed. (1970), p. 392.

(2) See Means (1935).

This does not mean that in the traditional setting price and quantity adjustments will not be observed to take place simultaneously. Rather, what is implicitly suggested is that where price adjustments are attenuated relative to what they would be under pure Walrasian conditions, the corresponding quantity adjustments will be increased relative to what they would otherwise have been.

The existence of this analytical tie does not in itself provide many answers. We need to develop the analysis further and focus on the particular relevance of industrial structure to the price adjustment process.

2.5 The Price Adjustment Decision

Our point of departure will be the distinction between competitive markets in the traditional sense of having market clearing agents, and industrial markets conventionally termed atomistic on account of their low level of seller concentration. It is generally accepted that competitive markets in the Walrasian tradition will display perfect price flexibility, as amply testified by price movements in commodity and stock markets.

Therefore, the problem of price adjustment exists in industrial markets as previously defined. In these, whether atomistic or oligopolistic, the price adjustment decision rests with each firm individually, although the potential action of its rivals needs to be taken into account. However, before examining the factors which affect the price adjustment decision we need to be more precise about the meaning of price flexibility. In the past, price flexibility has been defined in three different ways. First, it was associated with the number of times that prices were changed over an arbitrarily selected time period. Alternatively, it was related to the absolute magnitude of price movements over such a time period. Finally, taking an initial and final equilibrium price after an exogenous disturbance, price flexibility would be measured by the rate at which the final equilibrium price is approached. The latter is in effect a measure of the speed of adjustment and cannot be discussed in isolation from the magnitude of adjustment. From the literature, (Means 1972, Lustgarten 1975) it appears that the administered prices thesis relates largely to the directions and magnitude of price changes over selected time intervals.

In this section, the discussion will be concerned with price adjustments defined in a general sense. Thus we shall refer to price changes without distinguishing between the static and dynamic concepts.

A fundamental determinant of price adjustment, given changes in cost or demand, is the degree of uncertainty associated with those parameters. It will be argued here that this degree of uncertainty differs substantially between adjustments to changes in cost and in demand.

It is true that some uncertainty always exists as far as cost changes are concerned since at least some input prices fluctuate. But the degree of uncertainty for a given change in input prices is mitigated by the fact that once input prices are known, then cost conditions are internal to the firm. That is to say, even if a producer has no precise knowledge of his input-output relations, in principle his cost function can be estimated for a given set of input prices. Furthermore, once the cost-output relation has been determined for one set of input prices, it can be determined for any set.

With demand changes, these conditions are different. A rational price-output decision following a change in demand requires that the entire new demand schedule be known. However, this information is not internal to the firm and necessitates active search. A producer may observe a fall in demand at the current price, but he knows little about how demand now responds to a change in price. In addition, his demand schedule will be affected by action taken by his competitors which is subject to conjecture, whereas their response to cost changes cannot affect his unit costs.

To illustrate this problem consider the following example: firm i has a demand schedule which is given as:

$$(1) \quad q_i = a + \beta_1 p_i + z \qquad \beta_1 < 0 \qquad z = z(0,\sigma_z^2)$$

where q_i is demand, p_i is price and z is a random variable capturing such effects as random switching between sellers by buyers.

We can think of the firm as determining the parameters of its demand function a, β_1 and σ_z^2 through a learning process over time. Actual demand in each of its past trading periods constitutes a sample observation on which $\hat{a}$, $\hat{\beta}_1$ and the prior distribution of z are based. Since every change in demand is observed in terms of z, the question arises: at what critical value of z should the firm reject the null hypothesis that the parameters of its demand function have not changed? Supposing the null hypothesis is not rejected, then there is an additional question as to whether the variance of z is changing.

Hence the decision making problem is highly complex. A number of alternatives are open to the firm. First, it can perform a "hypothesis test" using its current observation on z, rejecting the null hypothesis if the test statistic exceeds a certain critical value. However, if the alternative hypothesis is accepted, the firm will not yet have sufficient information to determine the new values of $\hat{a}$ and $\hat{\beta}_1$.

On the other hand the firm may choose to increase the sample of observations on z before considering a permanent shift of its demand parameters. But this leads it into further decision problems for it now has to decide on the optimal stopping point i.e. when to stop collecting further observations on z. This is a complex question in information theory to which economic principles have been applied to derive optimal stopping rules. McCall (1965) and Stigler (1961), among others, have investigated the way in which optimal search criteria might be derived. It is noteworthy that both authors evinced that some prior knowledge on the relevant distribution of events being sampled is necessary before optimisation can take place.

Kirman (1975) has developed a duopoly model in which firms learn about demand conditions. By continually revising their estimates of the true demand parameters, the firms are shown to reach an equilibrium which is consistent with the one they would have reached had they been fully informed about their environment. In Kirman's model the information problem relates to ignorance about the effect of a rival's price on the firm's own demand, whilst overall demand conditions remain constant. The learning process may in fact be totally different when external demand conditions are changing and firms cannot predict their rival's responses to those market signals. Thus Kirman does not explore the fundamental question of uncertainty which concerns us here, namely, that the firm cannot determine a priori whether demand conditions in general have changed or whether it is experiencing the effects of rivals' predatory behaviour. In the event of general upswings or downswings in demand there is the additional problem of predicting the responses of other firms in the industry. The above discussion illustrates the problems of uncertainty associated with demand fluctuations in relation to those associated with cost changes.

It is clear that in an uncertain environment the problem of obtaining information is another important influence on the price adjustment decision. As suggested in the previous chapter, the signals which tell the firm that its decision variables are sub-optimal are in themselves insufficient for determining their new optimal values. Thus, unless it is to remain in disequilibrium, the firm must search for additional information on which it will base its adjustment decision.

Stemming from the recognition of uncertainty and lack of information in the firm's immediate environment, this subject has been widely discussed in the context of resource unemployment and its causes. Alchian (1970), referring specifically to the labour market, states that:

> "The key which, until recently, seems to have been forgotten, is that collating information about potential exchange opportunities is costly and can be performed in various ways."(1)

This remark is equally applicable to goods markets. In its efforts to restore equilibrium of its policy variables, the firm collects information, but this activity is costly. The information requirement is two-fold: the first relates to actual market conditions while the second relates to the need to estimate rivals' reactions, for ultimately the firm's optimal decision variables depend in part on those of its rivals. Together the amount of information required is considerable and as Leijonhufvud (1968) stresses, the conjectural problems facing firms are immensely complex.

The next question is: what factors influence the cost of obtaining information? One critical factor, it will be argued, is market structure. When firms determine their optimal price-cost margin they need to take into account the pricing decisions of rivals. They will recognise the benefits of collusion but they will also be aware of the costs of policing. When in disequilibrium through an exogenous change in demand, the firm requires information about rivals' adjustments. For if they do not react in accordance with the previously established pricing structure, the firm in question will need to revise its optimal decision variables. The problem

(1) Alchian, in Phelps ed. (1970), p. 28.

is then one of collusion costs where these are information costs. The latter will be influenced by market structure since where there are few firms the costs of obtaining information will be low. Stigler (1961) suggested that information costs increase with the size of the sample. This view was endorsed by Alchian (1970)(1), and hence it is not implausible to hypothesise that information costs rise with the number of firms in the industry. It is through the costs of obtaining information that the effect of market structure has a bearing on price adjustment. Its static and dynamic consequences will be developed in the price adjustment model. All that we have attempted to show here is that, in an uncertain environment, the costs of obtaining information are an important factor which influences the price adjustment decision.

The existence of uncertainty leads directly to consideration of risk attitudes as the third important influence on price adjustment. This point was raised by Arrow (1959) who stressed the impact of risk bearing capabilities of firms on the speed of adjustment. The survey of the extensive literature on risk and uncertainty suggests that attitudes towards risk will affect optimal policy variables. However, these effects are not easily generalisable, and they depend on a number of specific conditions such as the type of risk aversion or preference, the nature of the demand function and the like. Although it appears intuitively plausible that risk aversion should dampen price adjustments in favour of quantity adjustments, on the grounds of an unwillingness by the firm to alter a policy variable without being certain of its effect on profitability, the models discussed in the next chapter demonstrate that this need not be so.

A risk averter is defined as a decision-maker who prefers a certainty payoff π_s, to a range of payoffs each with a probability attached to it so

(1) To be discussed at length in the review of the literature.

that their expected value is $E(\pi_s)$. In order that $E(\pi_s)$ and π_s yield equal utility to the risk averter a risk premium must be added to $E(\pi_s)$.

We shall now consider a firm which is faced with an unanticipated increase in demand. At least initially, the firm will not know whether this increase is "random" in the sense of being temporary, nor can it predict how other firms are responding to this change. Therefore it is not implausible that a risk averse firm may leave price unchanged and simply increase quantity supplied subject to its capacity constraints.

However, a decrease in demand presents additional considerations. Firms may wish to avoid price reductions when demand falls because, when it picks up again and prices need to be restored to their former levels, they will need to consider the conjectural problems regarding rivals' adjustments. Thus, reducing prices in times of falling demand does not imply that they can be as easily increased when demand recovers. Although these arguments will not be developed further in this chapter, they indicate that attitudes towards risk in an environment of uncertainty and limited information need to be considered in the context of price adjustment.

So far, the analysis has been confined along traditional lines, to the use by the firm of two decision variables, namely price and quantity. However, in a world of product differentiation a discussion of price adjustment cannot omit two additional policy variables which are within the reach of the firm. These are advertising and quality change. Although usually viewed as part of the long-term corporate strategy of the firm, recent studies have suggested that these may also provide a useful tool for short-term competitive responses.

The basic theory underlying quality changes in this context is that in oligopolistic industries, where potential retaliation by rivals presents firms with a considerable threat, quality changes are a means of concealing price changes. Furthermore it is suggested by Cowling and Cubbin (1971) that quality changes are particularly effective as price reductions to which retaliation must necessarily be delayed by the length of time it takes to alter product characteristics.

To test this hypothesis hedonic price indices were used. Cowling and Cubbin (1972) showed that the quality adjusted price index for motor cars in the U.K. varied by more, over a selected time period, than the ordinary index published by the Department of Industry. The hedonic price index is derived by estimating a "shadow price" for each of the product's characteristics and then computing the predicted price on this basis. Thus if, when quality increases in terms of characteristics, the predicted price rises above the actual price, then a price reduction, in real terms, has been effected.

The relevant question is: how are quality adjustments used as policy variables? The proposition put forward by Cowling and Cubbin (1971) is that quality changes are used mainly in reducing price and that this vindicates the kinked demand curve hypothesis. The reasoning goes as follows: since firms are fearful of retaliation following price reductions, they choose to do so in real rather than nominal terms so that these are not easily detected, and when they are, a corresponding quality change by rivals would take a considerable period of time to implement.

Cubbin (1975) analysed the relation between quality changes and pricing behaviour for the U.K. motor industry over the 1956-68 period. Out of 147 price changes, 46 were decreases and 101 were increases. These were further split into quality changed-and-unchanged categories. Cubbin found that quality changes were more strongly associated with price decreases than increases, and this association was statistically significant. This evidence supports the view that quality adjusted price decreases are used as a means of avoiding oligopolistic retaliation. Firms will want to conceal price reductions, but they will want price increases to be followed by other firms. Hence quality adjustments will be used for reductions but not for increases. This is consistent with what Cubbin finds.

The argument could be carried a stage further by suggesting that quality changes could be used in response to short-term changes in demand for the reasons outlined above. However, if it takes several months to implement a modification of the product, then the firm runs the risk of realising a price adjustment when it is no longer required. Furthermore, Cubbin argued that quality-adjusted prices did not appear to respond to changes in sales or market share. This implies that quality adjustments are part of the long-run pricing strategy, rather than a short term adjustment tool. The ability of producers to disguise price decreases via quality changes also crucially depends on the characteristics of the product in question. Motor cars are particularly suitable for quality-adjusted-price competition.

To sum up, both on a priori and empirical grounds, it would appear that price adjustments via quality changes form part of the firm's medium-to-long term competitive strategy. As far as adjustments to short-run changes in demand are concerned, quality adjustments suffer from the same problems as pure price adjustments with one important exception: they are less easily detected and may not be as quickly neutralised.

Lastly, we have to consider advertising as an alternative or complement to the price adjustment decision. The static optimum ratio of advertising expenditures to sales revenue is determined by the ratio of the advertising to the price elasticity of demand. This is the familiar Dorfman-Steiner condition(1), which in itself says little about the potential trade-off between price and advertising adjustments to changes in demand. On the empirical side however, Cowling and Cubbin (1971) found that advertising expenditures responded to short-run changes in firms' market shares. But the latter reflect the effect of intra-industry competition rather than exogenous changes in demand which is what concerns us here.

On a priori grounds, it could be argued that advertising changes can provide effective short-run "stop-gap" adjustments to downward movements in market demand. First, advertising messages can be delivered in much shorter a time than say, quality changes take to implement. Also, the risks of making short-run adjustments to the price-cost margin which are difficult to redress are avoided by the use of advertising. However, the advertising decision is also subject to retaliation by rivals, particularly if market shares are closely guarded. Thus an adjustment to exogenous changes in demand may be mistaken for predatory behaviour by rivals hence inviting further retaliation. Of interest here is the finding by Cowling and Cubbin (1971) that advertising expenditures by U.K. motor manufacturers were sub-optimal in terms of the Dorfman-Steiner condition. The authors explained this finding by invoking the argument, previously suggested, that in a hostile retaliatory environment firms take account of the dangers of an advertising war and reduce expenditures accordingly. Hence the same argument would apply to the use of advertising as a short-run substitute to price adjustment. Again this would indicate that advertising is part of long-term, intra-industry competitive strategy

---

(1) For a concise restatement see Cowling et al (1975), pp. 5-6.

which firms may be unwilling to disturb in the face of changes in economic conditions which are shrouded in uncertainty.

2.6 Conclusions

In this chapter we surveyed the broad background to the price adjustment decision. We attempted to establish an association between the recent reinterpretation of the General Theory, known in the literature as the "new view" of Keynes, and the long-standing administered prices hypothesis. It was suggested that both controversies had common theoretical underpinnings and that they stemmed from the analytical confusion surrounding the theory of price adjustment in a non neo-classical market setting. This scenario is characterised by the problem of imperfect information which faces firms, and it is this information problem which links the present thesis with the ongoing controversies.

The gamut of factors which influence the price adjustment decision was explored in this chapter. Turning our attention away from quantity adjustments, we examined the effect of limited information, uncertainty, attitudes towards risk, quality changes and the role of advertising on the price adjustment decision. The overall conclusion which may be tentatively drawn is that in view of the environment in which the firm operates, it cannot rely on the different policy instruments listed above to provide a risk-free alternative to price adjustment. This is so because these alternative decision variables also carry with them the potential threat of competitive retaliation. Hence in the final analysis, quantity adjustments may provide the solution to the firm which is in short-run disequilibrium but which does not wish to disturb the competitive <u>status quo</u> in the industry by adjusting its price.

Further theoretical developments which will focus on the price adjustment decision and, in particular, on the problems of co-ordinating such adjustments with rival firms when information is scarce, will be presented in chapter 4. In the next chapter however, we shall present a review of the theoretical literature which is relevant to the price adjustment process.

Chapter 3

A REVIEW OF THE LITERATURE

3.1 Introduction

The subject of our thesis requires that the literature review should extend into two fairly distinct but complementary areas. The first concerns the pure theory of price adjustment. Until recently, there was no theory of price adjustment per se. In the formal work of Walras and Edgeworth, instantaneous price adjustment was guaranteed by certain theoretical assumptions. Following growing criticism of the time-honoured assumption that tâtonnement models with an impersonal market auctioneer adequately describe the adjustment of price, there has been a resurgence of interest in the subject with a number of recent contributions.

The second part of the literature review concerns the theory of decision making under uncertainty. Once we reject the assumption of an impersonal market agent adjusting prices to which all participants respond, the adjustment process is left squarely within the decision-making set of individual firms. It is not implausible to suggest, therefore, that the dynamics of adjustment are closely tied to the firm's attitude towards risk and uncertainty. This is because the firm faces the dual problem of imperfect information and a lack of certainty about the future outcome of current policy decisions.

3.2 The Pure Theory of Price Adjustment

The analysis of price adjustment has traditionally been linked to the fundamental theory of supply and demand. Adjustment was subsumed in the "law" in terms of the prediction that whenever demand exceeds supply prices will rise, and conversely when supply exceeds demand. This prediction was often verified in the literature by submitting evidence on price movements in competitive markets.

However, the more formal literature of the turn of the century recognised that this adjustment process required some very special assumptions about market structure. For example, Walras (1874) introduced the concept of a presiding auctioneer who would instantaneously and costlessly adjust prices in the market whenever the quantities supplied and demanded at a given price, "crié au hazard", were not equal. This special assumption ensured that exchange would always take place at equilibrium prices. Edgeworth (1881) used a similar assumption, namely that of "recontracting", to achieve the same end. Thus no contract was binding unless exchange in the market took place at equilibrium prices.

It is interesting to note that the dynamics of price adjustment were not explicitly discussed in the literature until Samuelson (1947) formalised the "law" of supply and demand in the well known price adjustment model which is given below:

$$(1) \qquad \frac{dp}{dt} = H(q_D - q_S) = H(D(p,\alpha) - S(p)) \quad H'>0$$

In equation (1) $D(p,\alpha)$ is the demand function and $S(p)$ the supply function. However, this differential equation of price adjustment did not constitute an attempt to formulate a theory of adjustment for markets in disequilibrium. Its purpose was the analysis of the stability properties of competitive price equilibrium. Using equation (1) Samuelson derived the Walrasian stability condition for a single market. A market was said to be Walras stable if, whenever quantity demanded exceeded quantity supplied, the price would rise. Thus the stability condition holds whenever, starting from disequilibrium, the equilibrium price is approached as time tends to infinity. Solving and simplifying equation (1) Samuelson was able to show that stability would be guaranteed by the positive slope of the supply curve, or in the event of it being negatively sloped, if it was less steep relative to the price axis than the demand curve. Samuelson also extended the stability analysis to the multiple market case, but the price adjustment specification remained the same.

The importance of Samuelson's contribution lies in the formal specification of the price adjustment process as in equation (1) The latter was to provide a focal point for critical reappraisal at a later stage.

Arrow (1959) took up the discussion by pointing to the fundamental inconsistency of the price adjustment model of equation (1). The inconsistency of the model arises out of a conflict with the central assumption of perfectly competitive markets, the behaviour of which it supposedly depicts. A perfectly competitive market is one in which sellers are price takers - they face an infinitely elastic demand curve at the current market price. However, equation (1) states that when supply and demand are unequal the market price will change. But since all sellers are price takers by assumption, there is no one left whose decision it is to change the market price in accordance with (1). Thus the crucial importance of having the Walrasian auctioneer is made evident; not only is the assumption necessary to guarantee that transactions occur at equilibrium prices, but it is also indispensable to ensure that market prices adjust instantaneously out of disequilibrium.

Arrow went on to explore the determinants of competitive price adjustment. He showed that whenever a market which would conventionally be classed as competitive is in disequilibrium, individual sellers become monopolists. To see this consider the situation of excess supply at the current market price. Some sellers cannot dispose of the output they wish to sell on the basis of equating price with marginal cost. They could increase their sales, *ceteris paribus*, by lowering their price. Clearly therefore, the price elasticity of demand which they face when the market is in disequilibrium is less than infinity.

Arrow specifically considered the situation of excess demand. Here each firm may be gradually increasing its price and quantity until the new equilibrium is reached. It was stressed that in disequilibrium each firm is tentatively feeling its way toward the new optimal price and quantity, so that different prices may prevail in the market simultaneously. Uncertainty about the true state of demand is the pervasive feature of the adjustment process.

Three factors were suggested to influence the speed of price adjustment. The first was the degree of capacity utilisation which would determine the rate of adjustment through its effect on the slope of the marginal cost curve. The second factor was the ability of producers to accumulate or run down their inventories. Finally, the third factor was the degree of uncertainty facing each firm, implying that the speed of adjustment will be an increasing function of the availability of information about demand.

Arrow's pioneering contribution left a number of questions unanswered. First, the problem of excess supply was not explored, yet this is a potentially more complex question. This is because while a risk averse firm facing excess demand may choose to ration its output among buyers or simply let some go without, a situation of excess supply involves a drain on the firm's resources with consequential pressures to adjust price or output. Furthermore, the problem of monitoring rival's behaviour was not given any attention. This is an important problem since in disequilibrium the outcome of any firm's policy decision depends also on what its rivals choose to do.

Gordon and Hynes (1970) prefaced their analysis of price dynamics by considering the Lange (1944) model of monopolistic price adjustment. In this model price adjustment is a function of the difference between marginal revenue and marginal cost, i.e.:

$$(2) \qquad \frac{dp}{dt} = G(R' - C') \qquad G' < 0$$

Gordon and Hynes questioned the validity of such an adjustment process on the grounds that if the monopolist possessed perfect information about marginal revenue and marginal cost he would instantly adjust the price. An alternative rationale for such a process was that the costs of adjustment would increase with the rate of price change, but they also found this argument unsatisfactory. It was their view that equation (2) could only be rationalised in terms of the very limited information available to the monopolist about his demand curve. Underlying equation (2) is the process of search for information about the relevant parameters for equilibrium price adjustment. They supported this view by pointing out that since transactions are discrete rather than continuous in time, the process of exploring the demand curve cannot take place instantly and costlessly by briefly changing the price. Therefore disequilibrium price dynamics arise out of "Knightian" uncertainty which implies that the parameters necessary for equilibrium adjustment are temporarily unknown.

Gordon and Hynes specified an expected demand schedule for the firm as follows:

$$(3) \qquad x^e = f^e(v, p, u_1, u_2, u_3, \alpha^e)$$

where x^e is expected demand, $v = (v_1 \ldots v_m)$ is a vector of information variables and the u's are random variables with zero mean and constant variance. Thus u_1, u_2, and u_3 represent the firm, industry, and aggregate demand respectively. Finally, α^e is an estimated shift parameter.

In their analysis of inflationary trade-offs the authors omitted u_1 and u_2 from equation (3) and assumed, for analytical convenience, that unpredictable shifts in demand result only from changes in monetary policy. They considered a once and for all increase in the nominal supply of money, and assumed that in order to restore equilibrium in the current period a 10% rise in money prices was required.

The first signs of disequilibrium will be excess demand and a rundown of inventories. A representative firm's demand schedule is given by equation (3) and it is assumed that the historically set price is consistent with an inventory level or its corresponding resource unemployment rate of U*. The shift in demand causes observed U* to fall to U'. The firm will increase its price but not by the 10% required, since past values of α^e still enter the expected demand schedule of x^e. The firm is assumed to possess a prior distribution of α^e which is continually modified in light of recent observation. The firm will learn that the excess demand is temporary because in successive time periods it will increase price by more than what is required to restore equilibrium. Thus it will then begin to observe excess supply, which will lead to a downward revision of α^e. In this manner the path to equilibrium is shown to be stable.

The authors stress that any disequilibrium states with unemployment above or below U* are transitory so that the authorities cannot use continual increases in the money supply to reduce U* permanently. If they attempt to do so the steady state inflation rate necessary to maintain dynamic equilibrium at U* will be incorporated by firms in their estimates of α^e. The net result will be an equilibrium level of unemployed resources U* with a stable rate of inflation. Hence the existence of a long run trade-off between inflation and unemployment is denied.

The hypothesis that individual decision-making units eventually learn about stable dynamic situations forms the basis for Gordon and Hynes' refutation of the widely used learning process known as the "adaptive expectations" model:

$$\alpha_t^e = \lambda \overset{\infty}{\Sigma} (1-\lambda)^i \alpha_{t-i} \tag{4}$$

This model (4) implies that current expectations always lag behind current observations. It would permit the authorities to establish a stable trade-off since, by changing demand in each period by a given percentage, firms' price adjustments would always lag behind thus maintaining a state of permanent excess demand.

However whilst rejecting (4), Gordon and Hynes do not rigorously specify the learning process of firms. In a world of uncertainty it is difficult to see how firms can form expectations which are always true to actual events.

The adaptive expectations model has the virtue of being consistent with the behaviour of risk averse decision makers. But although the authors argue that price inflexibility to demand changes is simply a reflection of the existence of uncertainty, they do not analyse explicitly the factors which underly this type of pricing behaviour.

Fisher's (1970) price adjustment model is set within a more abstract and rigorous framework, and its purpose is to examine the convergence of prices to the competitive equilibrium. In this model consumers search for low-price sellers and firms set prices on the basis of the observed difference between expected and actual demand. However, the way in which firms derive their expectations about demand constitutes the most fundamental and contentious assumption of Fisher's model. According to this assumption, each firm believes that it actually faces a horizontal demand curve at the equilibrium market price - but the latter is not known with certainty. Furthermore, each firm makes an independent estimate of the equilibrium market price, and then proceeds to supply up to the point where marginal cost equals the estimated price - p^e. Thus, if actual demand is less than expected, p^e is lowered. In the converse case when actual demand exceeds expectations, p^e is raised.

It is also assumed that low-price firms have at least as many customers as high-price firms so that search by consumers is efficient. Marginal costs are assumed to be constant ($c' > 0$) and identical for all firms. Finally it is assumed that consumers have the same demand curve and that there is a unique equilibrium price, $p^* > 0$, at which demand and supply are equal. For each firm the adjustment process is given as

$$\text{(5)} \qquad \frac{dp_i}{dt} = H^i(x_i)$$

where x_i is the excess demand facing the i'th firm. From this set of assumptions the following propositions are derived:

a) If two firms charge the same price p', they encounter the same demand.

b) If p_{min} is the lowest price charged by the set of firms and $p_{min} < p^*$, then for all firms charging $p_{min}, x_i > 0$.

c) If $p < p'$, and if for firms charging $p', x_i \geq 0$ then $x_i > 0$ also for firms charging p.

d) If p_{max} is the highest price charged by the set of firms and if $p_{max} \geq p_{min} \geq p^*$ then for firms charging $p_{max}, x_i < 0$.

e) For any $\varepsilon > 0$ there exists a $\delta > 0$ such that $p_{max} > p^* + \varepsilon$ and $p_{min} > p^* - \delta$ imply that for those charging $p_{max}, x_i < 0$.

The five propositions above follow almost directly from the assumptions. The propositions and assumptions are then used to prove the convergence theorem, which is as follows.

In this model, as time goes to infinity, all prices converge to the competitive price, p^*. This result is not surprising. It stems directly from two assumptions, the first about consumer search for low priced firms, and the second about firms behaving "as if" they were perfect competitors when they clearly are not. This latter assumption, that firms estimate an equilibrium market price at which demand is infinitely elastic, and its subsequent adjustment in light of excess demand, is difficult to rationalise. This behavioural assumption effectively ensures that firms can ignore the actions of rivals, since firm interdependence has no place in the model.

The analysis in the model thus concerns the convergence of different initial prices charged by firms to the unique competitive price. Of greater interest would be the analysis of adjustments by individual firms to changes in the relevant demand and cost parameters, but this aspect of price adjustment is not discused by Fisher.

Diamond's (1971) price adjustment model differs from Fishers' in two important respects. The first is the nature of consumer search. The second is the actual behaviour of firms. The model is one of discrete period optimisation. There are many firms and customers. In each time period a firm sets a price and a consumer enters the store at random. The consumer is uncertain about future prices. The cost of search is the disutility of further price sampling in future periods and is assumed to be an infinitely increasing function of search. In any time period every consumer has a cut-off price below which he will make a purchase in the current period. Thus search activity in this model is characterised as a time-process rather than a cross-section activity of searching for the lowest price store at any time. Consumer's utility is assumed to be a function of the price at which the purchase is made and the number of periods elapsed before purchasing. It is assumed also that all consumers have the same underlying demand resulting in a continuous quasi-concave firm revenue function with a maximum at a price p^* so that:

$p.\ x(p)$ increases for $p < p^*$ where $x(p)$ is demand

$p.\ x(p)$ decreases for $p > p^*$

For convenience, production costs are assumed to be zero. Denoting aggregate demand by $X_t(p)$ then if there are m stores each firm will face an identical demand curve given as:

$$(1/m)\ X_t(p)$$

This result is guaranteed by the nature of the search process described above. Since store search is random, it is rational for each firm to maximise profits discretely in each period. Its past and future prices will have no significant effect on current profits. Since all firms are assumed to have zero costs and identical demand curves, their optimal price in any period will be the same.

The crucial dynamic element of the model is the process of change in the cut-off price for existing consumers, and for those entering the market for the first time. In the former case it is assumed that a consumer who does not purchase in any one period, raises his cut-off price in the next period. This is justified on account of rising search costs in future periods which are a disincentive to the consumer's extension of price sampling. Those entering the market for the first time adjust their reservation or cut-off price on the basis of future price expectations. Since the latter are some weighted average of the former, the presence of search costs ensures that the reservation price of a new entrant will be higher than the current observed price.

Given these consumer search dynamics, Diamond shows that there exists a time period t' such that:

$$p_t = p^* \text{ for all } t > t'$$

In other words, firms' equilibrium prices converge to the joint profit maximising (monopoly) price. This result follows directly from the twin assumptions about firm and consumer behaviour, and stands in stark contrast to Fisher's result. This is because in Diamond's model, firms are aware that their demand curves are downward sloping, so that price changes have an effect on marginal revenue which is in direct antithesis to Fisher's "as if" perfectly competitive firms. Furthermore, in Diamond's model, the random, non-rational nature of the search ensures that firms can ignore the action of their rivals because, a) store selection is not based on past pricing history so consumers do not remember low price stores, and b) by the law of large numbers each store ends up with the same demand curve. Thus the search specification precludes any competition between stores.

On the other hand, Diamond's model shares some common drawbacks with Fisher's model. Both look at the convergence of an initial set of different prices to a unique equilibrium, and disregard the problem of adjustment following changes in underlying costs or demand. Both models abstract from problems of information on the firm's side and the relevance of risk-averse behaviour.

Fisher's 1972 model of price adjustment is essentially a general equilibrium extension of the single market, 1970 result. The scenario consists of n markets in each of which there are many "dealers" for the homogeneous commodity. These dealers set their price and then wait for buyers to come and transact with them. Dealers are generally sellers and customers are buyers, but the possibility of dealers buying is not excluded. As in the single market model each customer searches among dealers for the lowest price and the fundamental assumption is that every dealer believes that he faces a horizontal demand curve at the equilibrium price. He quotes a price believed by him to be the latter. If his estimate is proved wrong, he adjusts it in the direction indicated by excess demand. Consumer search is assumed to be costly, i.e. information has an opportunity cost. The set of dealers known to customers is assumed to be fixed over time thus guaranteeing a non-repetitive sampling process.

Although imperfect information may result in several prices existing simultaneously in any market at a given time, arbitrage is ruled out. Trade takes place instantaneously until all excess demands are zero. Continuity of the demand and supply function is also assumed. We denote $\bar{x}$ as quantity, $\bar{m}$ as initial money stock, z as excess demand, h as consumer subscript and i as commodity subscript. All superscripts denote dealers. The convergence theorem is preceded by three propositions:

a) A quasi-equilibrium is defined as a set of non-negative prices and stocks of $\bar{x}$ and $\bar{m}$ such that for every h and i,

$z_{hi} \leq 0$ and $\Sigma x_h = \bar{X}$ and $\Sigma m_h = \bar{M}$

b) A competitive-equilibrium is defined as a quasi-equilibrium in which for every i, $p_i^{\,d} = p_i^{\,r}$ i.e. all dealers' prices are the same.

c) Every quasi-equilibrium is also a competitive equilibrium.

This proposition is proved.

Using the above, Fisher demonstrates that every limit point of the prices path is a quasi-equilibrium and therefore a competitive equilibrium. Furthermore, if $p_i^d < p_i^r$ and $\Sigma z_{hi}^d > \Sigma z_{hi}^r$, then the economy is globally stable i.e. from any initial position it converges to competitive equilibrium.

This latter result is of crucial importance. It states that any deviation from equilibrium will be self correcting if and only if the consumer search process is efficient. This is defined such that if two dealers quote different prices, the dealer with the higher price will experience a lower level of excess demand than the dealer with the lower price.

The basic criticisms of the model apply equally to the 1970 partial equilibrium version. The greatest weakness is the assumption about dealers pricing behaviour - "as if" they were perfect competitors. Again the model concerns itself with convergence to a single equilibrium and does not consider adjustment from one equilibrium to another.

Barro's model (1972) differs from the Fisher and Diamond analysis in one significant respect: it recognises explicitly the monopolistic nature of disequilibrium price adjustments. Thus the demand curve facing the firm is stochastic and price elasticity is less than infinity. The distinguishing feature of Barro's analysis is a derivation of the difference in profit between a continual price adjustment profit function, and a static-price profit function. Price adjustments are considered in relation to changes in the stochastic component of demand. This cost of not adjusting price continually, i.e. the forgone profit, is then set against the cost of adjustment to derive the optimality criteria. The first step is to examine the effects of changes in the random component of demand u on profits:-

Demand schedule: $Y = Q(P) + u = \alpha - \beta P + u$

Cost schedule: $C(Y) = a + bY + cY^2$

Thus:

$$(6) \qquad \pi'(u) = P - C'(Y)$$

If u is varied from an initial value u_o to u_1 the corresponding change in profit is:

$$(7) \qquad \Delta\pi = \int_{u_o}^{u_1} \pi'(u)\, du = \int_{u_o}^{u_1} [P - C'(Y)]\, du$$

Using the explicit functional forms, equation (7) is computed for continual price adjustment and for a fixed value of P, $\hat{P}$, determined by u = 0 and unchanging when u_o becomes u_1. The difference between these is the profit gain from price adjustment:

$$(8) \qquad \Delta\pi_{(o,u)} - \Delta\hat{\pi}_{(o,u)} = \frac{(1 + 2c\beta)^2}{4\beta(1+c\beta)} u^2 = \theta u^2$$

It is assumed that price adjustment costs are purely administrative and therefore lump-sum (γ) independent of size or direction. Output adjustments have zero cost. The random component u is assumed to be generated by a symmetric random walk with constant time interval between steps, ζ. The firm then selects ceiling and floor values of demand, h_c and h_f, at which price adjustments occur. Since equation (8) is independent of α, h_c and h_f remain optimal after adjustment. If m denotes the number of adjustments over some time interval T, the expected cost per unit time will be:

$$(9) \qquad E(\text{Cost/Time}) = \gamma E(m/T) + E(\Delta\pi - \Delta\hat{\pi}) = \gamma E(m/T) + \theta E(u)^2$$

The firm selects $h = h_c = h_f$ (since costs are symmetric) to minimise the value of (9) above. Using some simplifications and approximations the latter can be rewritten as:

$$(10) \qquad E(\text{Cost/Time}) \simeq \frac{\gamma\sigma^2}{h^2} + \frac{\theta h^2}{6}$$

where σ^2 is the variance of the random walk and can be viewed as a measure of demand variability. The value of h^2 that minimises expected cost per time is:

(11) $(\hat{h})^2 = \sigma\sqrt{6\gamma/\theta}$

The next step involves using this result to determine the optimal relation between price change per unit time and current excess demand. This coefficient of price adjustment (k) is shown to be:

$$(12) \quad k = \frac{\sigma(1 + 2c\beta)^2}{4P\sqrt{6\gamma}[\beta(1 + c\beta)]^{3/2}}$$

This expression is the key result of the model. The coefficient of price adjustment k is positively related to demand variance σ^2, inversely related to adjustment costs γ and the price sensitivity of demand β. The reason for the latter is that a high value of β implying high demand sensitivity makes small price adjustments sufficient to re-attain equilibrium.

Although Barro's model scores in that it emphasises the monopolistic nature of price adjustment it shares some shortcomings with the Diamond and Fisher models. The model considers only changes in the random component of demand u and their effect on price; changes of the cost and demand coefficients b and β on adjustments are not analysed. Furthermore the problem of rivals' actions and their effect on the adjustment process is entirely ignored by virtue of the assumption that the firm is a monopolist. Finally the firm is taken to be maximising its current profits. No allowance is made for risk averse behaviour and the trade-off which it implies between output and price adjustment.

Hey (1974) has developed a price adjustment model using the Diamond and Fisher framework but modifying the specification of consumer search and firms' pricing strategy. It is assumed that firms know that they face downward sloping demand curves. The position of each firm's demand curve depends on its own price relative to that of its rivals. Consumer search is costly. k is the optimal number of firms searched, the same for all consumers. It is derived through the trade-off between disutility of seach and increased expected utility from lower price. Price is denoted x, and its distribution function among firms $F(x)$, with a density function $f(x)$. Denoting $g(x/k)$ as the probability density of the lowest price in a sample of k firms, it is stated that:

$$(13) \qquad g(x/k) = kf(x)\left[1 - F(x)\right]^{k-1}$$

If N is the ratio of buyers to sellers, the ratio of customers to firms at any price x is given by:

$$(14) \qquad R(x/k,N) = N.g(x/k)/f(x) = N.k[1 - F(x)]^{k-1}$$

Clearly this ratio depends only on N, k and $F(x)$. This means that assuming N and k are constant, if a firm remains at the same point in the distribution of prices it will have the same number of customers in any two periods. The firm's demand curve is given as $D(x) = R(x/k,N).d(x)$ where $d(x)$ is the consumer's demand curve - identical for all consumers. Assuming these have constant demand elasticity θ, and firms maximise profits with constant marginal costs γ; then the profit maximising price is:

$$(15) \qquad x' = \gamma\frac{\theta}{\theta - 1} = \gamma\delta \quad \text{where } \delta \text{ stands for } \frac{\theta}{\theta-1}$$

However, since different firms charge different prices but have identical costs they must have different perceptions of δ with those charging higher prices having higher estimates of δ. Each firm's estimate of δ, denoted as δ^*, is assumed to be revised according to an adaptive expectations model in multiplicative form i.e.

$$(16) \qquad \delta^*_{t+1} = \delta^{*\lambda}_t \delta^{1-\lambda}_t$$

$$\text{or} \qquad \log \delta^*_{t+1} = \lambda \log \delta^*_t + (1 - \lambda)\log \delta_t$$

The author then draws upon the result that if in period t the price distribution is Pareto, and if all firms change their prices according to an adjustment process given as:

$$(17) \qquad x'_{t+1} = a_t x_t^{b_t}$$

then the price distribution in period t+1 will also be Pareto. In addition we note that all firms observe the same price elasticity θ.

From (15) above we have that $x'_{t+1} = \gamma\delta^*_{t+1}$ and substituting for δ^*_{t+1} in the above expression we obtain:

$$(18) \qquad x'_{t+1} = \gamma\delta^{*\lambda}_t \, \delta^{1-\lambda}$$

However, since $\delta^*_t = x_t/\gamma$, expression (18) can be rewritten as:

$$(19) \qquad x'_{t+1} = (\gamma\delta)^{1-\lambda} x^{\lambda}_t$$

Expression (19) is equivalent to (17) with $a = (\gamma\delta)$ and $b = \lambda$. Thus the key result of this model is that the limit of this adjustment process is a degenerate distribution at the single value of $\gamma\delta$ i.e. the monopoly price. The speed of convergence to $\gamma\delta$ clearly depends on λ.

Hey's model resembles those of Fisher and Diamond in that the analysis centres on a convergence theorem to a unique equilibrium market price. The main difference lies in the price adjustment process ascribed to firms and the pattern of consumer search.

The main drawback with Hey's model is that the result depends crucially on firms remaining on the same point of the price distribution through time, and this latter condition will only be guaranteed if N, k and F(x) remain constant through time. It is not difficult to accept that N may not change over time if the number of buyers and sellers is very large; but the same cannot be said of k and F(x). The author himself suggests that k will change as consumers learn through the sampling process, and for F(x) to remain unchanged very special assumptions are required about the price adjustment process of firms and the initial distribution of prices.

The problem of rivals' action and its effect on each firm's adjustment process is removed by assuming identical, constant elasticity demand curves for all consumers in conjunction with the assumption of a constant ratio of customers to firms. Finally, in common with the Fisher and

Diamond models, Hey abstracts from the question of price adjustment to changes in perceived costs and demand. The analysis rests on deriving a convergence theorem from an initial distribution of prices. To that extent, therefore, the models abstract from the central question of price adjustment as originally posed by Arrow.

Excluding the contributions by Arrow (1959) and Gordon and Hynes (1970), the recent models on the subject of price adjustment suffer from three related drawbacks. First, the models do not specifically consider the problem of disequilibrium price adjustments induced by changes in the cost and demand parameters. Second, within a realistic decision making framework the question of risk aversion by firms, imperfect information, and rivals' reactions cannot be ignored, but the models do not examine these problems. Finally, within the context of temporary market imperfections during disequilibrium, the potential trade-off between price and quantity adjustment as suggested by Leijonhufvud (1968) and Hines (1971) needs to be rigorously examined.

3.3 The Theory of Decision Making by the Firm under Uncertainty

The assumption that price adjustments can be viewed "as if" effected by impersonal market agents has come under increasing criticism in recent years. The traditional scenario was that price adjustments per unit time were a function of the gap between supply and demand. A consensus is now emerging regarding the inadequacy of this scenario for the analysis of adjustments in modern industrial markets. It is now widely recognised that firms in these markets make price and quantity adjustments individually - that is in isolation from but not without recognition of their rivals. This conceptual change leads to the question of a realistic framework within which the analysis of price adjustments can take place.

For the firm considering an adjustment of its policy variables to a new optimum there exists a two-fold decision making problem. The first concerns imperfect information. This arises because an essential feature of market disequilibria is that the signals which reveal to the firm the change in its environment are themselves insufficient for determining the new optima. In other words even if a firm observes that it is out of equilibrium, it will nevertheless not have sufficient information to get back to it. For optimal adjustment, the firm needs to search for and acquire additional information. However, search is a costly activity and hence it must be explicitly considered as part of the decision making process.

The second problem, distinct from the first, is that even if full information were obtained, the stochastic nature of economic phenomena means that the success of policy decisions could not be determined with certainty. This is particularly relevant in a dynamic context where the result of current decisions only emerges at a future date. Thus for each decision taken there is a range of potential outcomes, each of which has a probability attached to it. The gathering of additional information would make the probability statement more definitive but it would not render potential outcomes deterministic, i.e. certain.

Firm decision making is therefore subject to some "uncertainty" - loosely defined. Hence it is clear that the firm's attitude towards risk is crucial as regards its decision making.

Rigorous analysis of the economics of information began with Stigler's seminal contribution in 1961. The basic premise adopted by Stigler is that information is scarce and therefore has an opportunity cost. Given that the decision-maker requires information before he can take decisions, his first problem is to determine what amount of search activity is optimal. Since information yields benefits but is also costly, an economic problem is involved in deriving an optimal quantity of search activity.

Stigler's framework is as follows: consumers search among stores in order to discover low priced stores. The problem is when to stop searching. The distribution of store prices is known _a priori_. An additional assumption is that at any time there will be a frequency distribution of prices quoted by sellers and that the dispersion of prices is sufficiently large to provide an adequate incentive for consumers' search of low priced dealers.

Stigler specifically considers a case where the distribution of sellers' prices is uniform between zero and one. Using the statistical properties of this distribution he shows that the distribution of minimum prices with n stores being searched is:

$$(20) \qquad n(1-p)^{n-1}$$

where p is price. In deciding on the number of stores which would constitute an optimal amount of search, the consumer has to take account of the expected benefit of additional search as compared to its cost. Thus the relevant question relates to the expected minimum price of n stores searched. For the uniform distribution and from (20) above this is given as:

$$(21) \qquad E(p_{min}(n)) = \frac{1}{n+1}$$

Clearly the expected minimum price declines with additional search but at a decreasing rate. Stigler then shows that this result also applies to rectangular and normal distributions of sellers' prices. For the consumer, the optimal number of stores searched is obtained when the expected benefit of an additional store searched equals the cost of the search. Assuming the latter to be constant and denoting it by (c); assuming also that the expected gain of search is the saving incurred thereby i.e. quantity purchased (q) times the unit reduction in price, then it is optimal to search n stores if

$$(22) \qquad E\left[p_{min}(n-1) - p_{min}(n)\right]q \geq c > E\left[p_{min}(n) - p_{min}(n+1)\right]q$$

As Stigler puts it:

> "If the cost of search is equated to its expected marginal return, the optimum amount of search will be found."(1)

---

(1) Stigler (1961), p. 216.

There seems to be no problem in assuming the costs of search to be proportional to the number of sample units. More contentious is the assumption adopted by Stigler that the distribution of sellers' prices is known a priori, so that expected minimum prices can be determined. Stigler is in fact assuming that consumers already have a significant amount of relevant information.

In the wake of Stigler's contribution it has been suggested that the fixed-sample search rule is not optimal and should be substituted by a sequential sampling process (notably McCall 1965). Thus if the present minimum price is s, and if the expected decrease in minimum price from additional search is g(s), then it pays to search continually until $c \geq g(s)$. However, it appears that the optimality of this decision rule depends on the amount of prior information which the consumer has on the distribution of sellers prices.

While Stigler's analysis opened up a number of interesting questions, as Rothschild (1973) points out in his survey article the important question of why a dispersion of sellers' prices should persist is not given any attention. Its importance stems from the fact that with efficient search by consumers and competition among firms, the distribution of prices would shrink to a point. Hence the particular conditions relating to the persistence of sellers' price distribution require analysis. Stigler's model is therefore said to relate to one side of the market only. From a price adjustment viewpoint the question of sellers' search is of great relevance.

The problem of information and its specific implications for macroeconomic aggregates has cropped up in the unemployment disequilibrium literature with most noteworthy contributions by Leijonhufvud (1968) and Alchian (1970). These discussions address themselves primarily to the question of resource unemployment following reduction in aggregate demand.

Alchian interprets the emergence of labour unemployment in terms of the costs of gathering information about potential exchange opportunities.

He suggests that these costs account for the setting up of institutions such as markets and commodity exchanges, for these minimise the costs of generating information by bringing buyers and sellers together.

Alchian proceeds to lay down two central propositions in connection with information costs. First, dissemination and acquisition of information obeys the ordinary laws of production, i.e. the faster the rate the higher the cost. This is illustrated by a simple example. Given the sampling distribution of buyers' offers, as the sample is enlarged the observed maximum offer will increase but at a diminishing rate.

Second, the costs of collecting and disseminating information are reduced through specialisation in this activity. Thus in relation to a person seeking a job, this is more efficiently done while that person is unemployed and able to "specialise" in collecting and disseminating information. Alchian suggests this as a reason why it may be economic to refuse a salary cut and become unemployed whilst looking for another job.

The author also suggests that in many cases price stability, with its associated need for inventories and queues, has an economic justification because such stability minimises the costs of search by customers. If retailers always adjusted prices to clear their stocks, customers would be faced with a different distribution of store prices in each period, so that search will be required in each period. Thus greater search will be required when prices are relatively unstable. Consumers may be willing to trade off disutility of queuing against the costs of extra search necessitated in order to find low priced stores. Hence a seller who willingly stabilises his prices, offers his customers savings in terms of reduced search costs.

Of special relevance to this thesis is the suggestion that quantity-adjustments may replace price-adjustments in the exchange process where the problem of search is explicitly introduced into the optimising calculus of economic agents. The same suggestion is more forcefully made by Leijonhufvud (1968) in his theoretical reappraisal of the Keynesian contribution to the theory of exchange. Whilst Alchian confines himself to customer and employee search costs and their effect on optimisation, Leijonhufvud goes a step further to recognise the fact that:

> ".... atomistic markets in disequilibrium present individual transactors with conjectural problems of immense complexity".[1]

Thus although both authors stress the importance of search for information they do not relate it specifically to what concerns us here, namely the need for information on rivals' behaviour and changes in demand.

The literature on decision making under uncertainty has been extensively developed in recent years. Its essential feature consists in comparing the utility of choices between outcomes which are known with certainty and those to which probabilities are attached. This approach stems from the Von Neumann-Morgenstern analysis of utility measurement, and its widest application has been in the study of decision making involving risk.

The two classical contributions in this field are by Pratt (1964) and Arrow (1965). As their respective papers are fairly close substitutes, we will review Arrow's work and draw the parallels with Pratt's work where appropriate.

The starting point of Arrow's analysis rests on the fundamental proposition that the utility of an action to which a finite number of possible outcomes are attached with different probabilities, is equal to the weighted average of the utilities of these outcomes. The weights are the respective probabilities. Thus, call the probability of an event i P_i, wealth π, and U utility, then the formal expression of the proposition is:

$$(23) \qquad U\left[\sum_{i=1}^{n} P_i(\pi_i)\right] = \sum_{i=1}^{n} P_i\left[U(\pi_i)\right]$$

(1) Leijonhufvud (1968), p. 77.

Note that the R.H.S. of (23) is the formula for expected utility $E(\pi)$.

Now the analysis of choices involving risks consists of comparing the utility derived from a payoff which is certain with another which is probabilistic. For example if an individual is indifferent between a given wealth π_j and a collection of possible wealth values with an expected value of π_j i.e. $E(\pi_j)$, then we say that the individual is risk neutral. The stochastic (probabilistic) nature of his payoff does not effect his utility.

Thus if:

$$(24) \qquad U(\pi_j) = U\left[E(\pi_j)\right] = U\left[\Sigma_j P_j(\pi_j)\right]$$

then the decision maker is risk neutral.

This analysis provides a basis for an evaluation of the nature of the utility function of a risk-averse individual. For the latter the utility of an outcome known with certainty will not be equal to its equivalent expected value, i.e. the risk averse decision maker will always prefer the certain outcome. Thus for him:

$$(25) \qquad U(\pi_j) > U\left[E(\pi_j)\right]$$

Arrow's specific example incorporates a positive increment of wealth (h), and his equivalent statement to (25) is as follows:

$$(26) \qquad U(\pi_o) > (\tfrac{1}{2})\, U\left[\pi_o - h\right] + (\tfrac{1}{2})\, U\left[\pi_o + h\right]$$

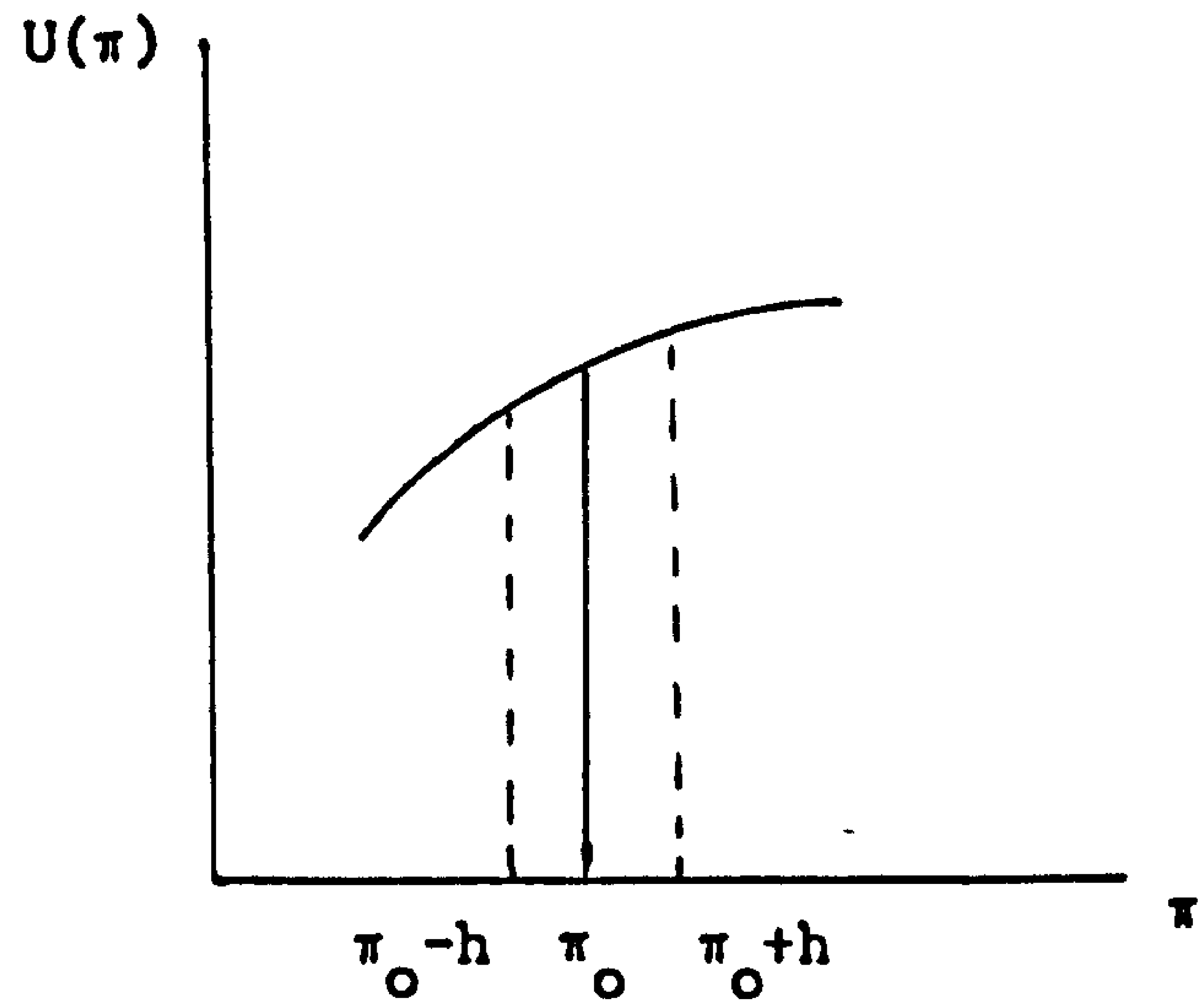
In other words risk aversion implies preference of π_o over an equal chance ($\frac{1}{2}$) of getting $\pi_o - h$ and $\pi_o + h$. Rearranging (26)we have:

$$(27) \qquad U(\pi_o) - U(\pi_o - h) > U(\pi_o + h) - U(\pi_o)$$

It can be seen that (27) implies a utility function which is concave to the origin as depicted in the diagram below:

Figure 3.1

A Concave Utility Function



This property of risk aversion, namely diminishing marginal utility of wealth, can be used to derive an index of the aversion to risk. The second derivative of the utility function $U''(\pi) < 0$ could be used as such an index, but as Arrow pointed out, the numerical value of $U''(\pi)$ will vary with the numerical value of the utility function $U(\pi)$. To get around this problem Arrow proposed two measures of risk aversion which remain invariant under positive linear transformations of $U(\pi)$:

$R_A(\pi) \;=\; -U''(\pi)/U'(\pi)$ is the coefficient of absolute risk aversion

$R_R(\pi) \;=\; -\pi U''(\pi)/U(\pi)$ is the coefficient of relative risk aversion

Both Arrow and Pratt demonstrate that the coefficient of risk aversion corresponds to a risk premium with which an individual must be compensated if he is to accept the risky alternative. Pratt considers an individual who is faced with a random income of an expected value $E(Y)$, and a certain income, Y_o. A risk averter would be willing to accept a value of Y_o somewhat less than $E(Y)$ and this difference may be thought of as the risk premium, P.

Thus $\quad P = E(Y) - Y_o$

Pratt then goes on to show that:

$$(28) \qquad P \;=\; 1/2\ \sigma_Y^2\ R_A(Y_o) + \text{terms of higher order.}$$

From this expression it can be seen that the risk premium increases with the degree of risk aversion.

Mills (1959) developed a model of decision making under uncertainty which was not cast in the utility of profit framework. In what was the earliest contribution in this area, Mills examined the optimal price and output decisions of the firm which faces a stochastic demand schedule.

In Mills' scenario the firm determines optimal price and output in advance of the trading period, that is before demand can be observed. He lays stress on the fact that a true state of uncertainty would not exist if the firm only had to determine in advance one policy variable, letting the other find its own equilibrium ex post. The demand schedule is defined as follows:

$$(29) \qquad x = x(p) + u \qquad E(u) = 0$$

where x is quantity demanded and u is the random variable with zero mean. Since this is a one period model the problem of inventories is ignored. The firm is assumed to maximise expected profits, which implies that, since $E(u) = 0$, the optimal price set by this expected profit maximiser and that of the firm which faces certain demand will be the same. This is because, on average, the random variations in demand are zero, and the expected profit maximiser is only concerned with the mean values of the variables.

However, Mills' innovation consists of introducing uncertainty into the model through the specification of the expected revenue function. He distinguishes between actual demand (x) and output produced (z), since these will generally not be the same. Thus, total realised revenue will be equal to:

$$(30) \qquad R^*(z,p) = \begin{cases} px & \text{if } x \leq z \\ pz & \text{if } x \geq z \end{cases}$$

In this model it is explicitly recognised that demand may exceed output produced. Expected profits will be given by:

$$(31) \qquad E(\pi) = px(p) - pD(z,p) - c(z)$$

where $D(z,p)$ represents the shortage function, that is, the mean revenue lost due to unsatisfied demand and $c(z)$ are the costs of producing z.

The next step is to derive the optimal values p^* and z^* in the uncertainty case and compare them with their certainty equivalents. In the certainty case, optimal price $\bar{p}$ is that which equates riskless marginal revenue and marginal cost i.e.:

$$(31) \qquad x(\bar{p}) + \bar{p}x'(\bar{p}) = c'(z)x'(\bar{p})$$

In the case where demand incorporates a random component the first order condition for expected profit maximisation is:

$$(32) \qquad \frac{x(p^*)}{x'(p^*)} + p^* = c'(z) + \frac{D(z,p^*)}{x'(p^*)}$$

From the above expression it can be seen that in the uncertainty situation the firm equates marginal revenue to marginal cost plus a second term. Since the latter is negative, it can be seen immediately that the optimal price p^* will be lower than in the certainty case. Mills then proceeds to generalise this result and shows that usually, but not invariably, the optimal price p^* will be lower than $\bar{p}$. However, optimal quantity produced in the uncertainty case z^* may be equal to, greater than, or less than its certainty equivalent $\bar{z}$ depending on the nature of the demand schedule and the marginal cost curve.

The notable feature of Mills' model is that it analyses the effect of uncertainty on decision making without assuming risk aversion on the part of firms, given that the objective function involves maximising expected profits. The particular result shown above, i.e. $p^* \leq \bar{p}$, stems from the fact that a fall in price, whilst increasing total expected revenue, also increases the expected shortfall of production, i.e. shortage. Since the latter is a cost in terms of lost revenue, the producer balances these two effects in deriving the equilibrium values of the decision variables, i.e.

the optimal price p^*. The net effect is the lower price p^* than that under the certainty model. Mills' result therefore depends crucially on the existence of positive expected shortage. If p or z were large enough to make shortage impossible then we would have $p^* = \bar{p}$.

In Horowitz (1970) an entire chapter is devoted to the subject of price-quantity determination under uncertainty. Much of the discussion consists of a review of previous work, but Horowitz's own contribution is also included. A distinction is made at the outset between price taking and price quoting firms and those with linear and non-linear risk preferences.

The starting point of the analysis consists of a presentation of Mills' model which has already been discussed. Even though Mills' firm is risk-neutral, uncertainty leads to results which are in stark contrast to the certainty case.

In the context of non-linear risk preferences Horowitz discusses the contribution by Hyman (1966). Hyman's scenario is that of random demand and uniform competitive price, P, which firms cannot influence. Hence it is a price-taker model. Unsold output is scrapped so there is a cost to overproduction. Optimal output is determined by maximising utility of profit function $U(\pi)$ with respect to output. This is established when:

$$(34) \qquad P\left[\frac{\int_{Q^*}^{\infty} U' \, f(Q)dQ}{\int_{0}^{\infty} U' \, f(Q)dQ}\right] = \frac{dC}{dQ^*}$$

where $U' = U'(\pi)$. The term in the squared brackets appears because, as in the Mills model, there is a cost imputed to discrepancies between output and demand. It is then shown that a risk-averse firm will have a smaller output than a risk neutral firm. Furthermore since the term in square brackets in (34) above is less than one, this implies that at optimal output $P > dC/dQ^*$, which implies that the price-taking firm under uncertainty produces less than it would under certainty. However as the firm's willingness to accept risk rises the bracketed expression approaches unity so that optimum output approaches its certainty equivalent.

In Dhyrmes (1964), price is the random variable and the firm has to determine the optimal output level. The firm's attitude towards risk is expressed in terms of a utility function quadratic in profit, which under the assumption of additive random demand simplifies to:

$$(35) \qquad E(U) = \pi(Q) + \tfrac{1}{2}\,\alpha Q^2 \sigma_u^{\,2}$$

where α is to be interpreted as the propensity to accept risk. With $\alpha = 0$, the firm is risk neutral and with $\alpha < 0$ the utility function is strictly concave and the firm is a risk-avoider. The first order condition for maximising (35) with respect to Q yields an optimal quantity produced which satisfies the condition:

$$(36) \qquad MR = MC - \tfrac{1}{2}\,\alpha\, Q^2 \sigma_u^{\,2}$$

Thus if $\alpha = 0$ we get the certainty result MR = MC. For $\alpha < 0$ we note that the risk-avoider will produce an output lower than under certainty. Dhrymes' result is therefore consistent with that of Hyman.

We turn now to Horowitz's own contribution (1970). His model relates to the price quoter and he stresses the relevance of this institutional setting by suggesting that:

> "price quoting behaviour would seem to be the prevailing <u>modus operandi</u> of the business world".(1)

It is assumed that at any price, P, demand, Q, is a random variable. The firm attempts to satisfy all the demand at the optimal price P* with the qualification that with rising marginal costs, production will be halted at Q_m, where price equals MC. Hence under rising MC expected profits are not equal to price times expected demand minus costs. Instead we have:

$$(37) \quad E(\pi) = \int_0^{Q_m} (PQ - C(Q))\, f(P;Q)\, dQ + (PQ_m - C(Q_m)) \int_{Q_m}^{\infty} f(P;Q)\, dQ$$

Horowitz shows that maximising the above expression with respect to P for the risk neutral firm the resulting optimum is equivalent to the certainty

(1) Horowitz (1970), p. 393.

case. The firm quotes a price P^* which gives an expected output $E(Q^*)$ at which a species of marginal revenue is equated with a species of marginal cost.

The firm with non-linear risk preferences maximises an objective function of the form:

$$(38)' \quad E[U(\pi)] = \int_0^{Q_m} U(\pi)\, f(P;Q)\, dQ + U(\pi_m) \int_{Q_m}^{\infty} f(p;Q) dQ$$

As Horowitz shows, it is difficult to generalise the effects of non-linear risk preferences on the decision variables. A risk-evader may prefer a higher or a lower optimal price than a risk neutral firm, depending on the utility function of the firm and the cost and demand functions. This result is consistent with that of Leland (1972) which will be discussed below.

Of particular interest is Horowitz's analysis of the effect of a change in demand on optimal price. The type of demand change considered is a shift in the entire distribution $f(P;Q)$ so that expected demand is higher at every price. Horowitz demonstrates that a risk neutral firm will increase price for upward demand shifts provided marginal cost is not a decreasing function of output, in which case a price decrease is possible.

For a risk-evader generalisations are again difficult to make. If $d^2C/dQ^2 > 0$, there is a likelihood of a price increase when demand rises.

Horowitz's survey demonstrates that a variety of results is possible when uncertainty and attitudes to risk are introduced into the decision making process. Notably absent from these discussions are considerations of uncertainty induced by interaction amongst competing firms in an industry.

A more specific model of the firm under uncertainty has been constructed by Sandmo (1971). The firm is assumed to maximise utility of profit $U(\pi)$ and a fairly general form of risk aversion is introduced by specifying $U'(\pi) > 0$ and $U''(\pi) < 0$. The firm's profit function is:

$\pi(x) = px - C(x) - B$ where B = fixed costs. Price is taken to be the random variable with a density function $f(p)$ and mean $E(p) = \mu$. The firm is therefore a quantity-setter with price freely determined <u>ex-post</u>. The first order condition for utility maximisation is:

$$(39) \qquad E\left[U'(\pi)\,(p - c'(x))\right] = 0$$

Assuming risk-aversion on the part of firms, Sandmo then examines the effect of uncertainty on optimal output. Under certainty, price would be equated to marginal costs, while under uncertainty, Sandmo demonstrates that the condition for optimal output is: $c'(x) \leq \mu$ where $\mu = E(p)$. Thus, marginal cost is less than expected price which implies that optimal output is less than its certainty equivalent. Sandmo also shows that decreasing absolute risk aversion (R_A) is a necessary and sufficient condition for fixed costs to affect the decision variable (x), in contrast to the certainty case where fixed costs have no influence. Similarly, an increase in the tax rate will increase, leave constant, or reduce output depending on whether relative risk aversion (R_R) is increasing, constant, or decreasing. Sandmo's result is consistent with those of Hyman and Dhyrmes which were reviewed above.

Leland (1972) has generalised the analysis of firm behaviour under uncertainty to cover both price and quantity setting firms. Demand is assumed to be random and Leland also invokes the "principle of increasing uncertainty" which is crucial to the analysis. The "principle" implies that, as total expected revenue increases, so will its dispersion. The demand function in its implicit form is: $f(p,q,u) = 0$. The first case examined by Leland is the quantity setting firm - i.e. optimal output is determined ex ante. Profits are given as: $\pi = p(q,u,)q - C(q) - f$, where f represents fixed costs. The firm maximises the expected utility of profit and the first order condition for a maximum with respect to q yields:

$$(40) \qquad E\left[\left[MR(q,u) - MC(q)\right]\ U'(\pi)\right] = 0$$

where MR is marginal revenue and MC marginal cost.

In order to compare optimal quantity under uncertainty with its certainty equivalent, Leland defines certainty demand as the expected-price demand curve. Taking the firm facing certainty demand to choose optimal output q_c, Leland shows that optimal output under uncertainty will be smaller than q_c if the first order condition (40) is negative when $q = q_c$. If the principle of increasing uncertainty holds, this will be the case provided the firm is risk averse, i.e. ($U''(\pi) < 0$). Thus risk aversion and uncertain demand implies lower optimal output than under certainty. The converse is proved for risk preferring firms. This result accords with the ones previously cited.

The price quoting firm is considered next. In this case profit is given as:

$$\pi = pq(p,u) - cq(p,u) - f$$

Maximising this function with respect to p gives:

$$(41) \qquad E\left[U'(\pi)\,(\partial\pi/\partial p)\right] = 0$$

If we assume that the optimal price under certainty is p_c, then the deviation of the optimal price under uncertainty from p_c depends crucially on attitudes towards risk. However, in contrast with the quantity setting firm, the shape of the cost curve is also critical in determining optimal price. With risk neutrality, $U'(\pi)$ is constant for all π. Leland demonstrates that for a risk neutral firm with constant MC, uncertainty does not affect optimal price, but if MC rises at a non-decreasing rate, optimal price will rise above its certainty equivalent.

With risk aversion the analysis is considerably more complicated. If p_u is optimal price for the risk neutral firm, then with risk aversion optimal price will be greater than, equal to, or less than p_u depending on whether the first order condition (41) is greater than, equal to, or less than zero evaluated at p_u.

The conditions affecting the sign of (41) are complex and cannot be generalised. For a specific example of a demand curve additively separable in p and u, and with non-decreasing marginal costs, Leland shows that optimal price for the risk averse firm will be lower than under uncertainty. Thus Leland's model extends in scope and degree of generalisation much of the previously reviewed work on decision making under uncertainty.

From the above discussion it is clear that all the models with identical scenarios yield similar results. Yet the striking impression which emerges from the literature is that a variety of results may be obtained regarding the influence of uncertainty on pricing behaviour, and consequently it is not possible to make meaningful generalisations. In effect, the particular influence of uncertainty on decision making depends largely on the type of model being considered.

3.4 Concluding Remarks

In this chapter we presented a fairly extensive review of the literature which is relevant to the analysis of price determination and adjustment. In the first section we examined a number of recent contributions to the burgeoning literature on the pure theory of price adjustment. The main thrust of these lies in the derivation of convergence theorems to the single competitive or monopoly price based on special assumptions about the behaviour of market participants. Our major criticism of this approach was that the behavioural assumptions adopted by these authors, e.g. Diamond and Fisher, were highly contentious and were not compatible with a realistic scenario of industrial organisation. Their analysis of the price adjustment process is therefore hindered by the institutional environment which they consider and the behavioural patterns which they assume. By contrast, the objective of this thesis is to examine the adjustment process in a realistic industrial setting and to pay special attention to the problem of imperfect information.

On the question of uncertainty, the literature reviewed in this chapter indicated that since the effect of uncertainty on the optimal price is ambiguous and depends on the type of model being considered, its influence on the price adjustment decision is also likely to be ambiguous. However, uncertainty is closely related to the problem of imperfect information about rivals' behaviour, and we shall examine its influence as part of our theoretical analysis in the subsequent chapter.

In summing up it may be appropriate to quote Rothschild's conclusion, from his extensive survey article, that the only generalisation which can be unambiguously stated is that uncertainty does influence firm behaviour:

> "Although the different models studied lead to an embarrassing diversity of conclusions, they agree on the basic proposition that uncertainty does affect firm decision and hence short-run industry equilibrium."[1]

(1) Rothschild (1973), p. 1,291.

Chapter 4

A THEORETICAL ANALYSIS OF PRICE ADJUSTMENT

4.1 Introduction

The distinguishing feature of the theoretical analysis in this chapter is the explicit role which is assigned to search activity in the decision making process. Like the determination of equilibrium price, the adjustment decision in a non-Walrasian environment cannot be taken without acquiring information relating to the true state of disequilibrium and the likely behaviour of competitors. But the search for information which this necessarily involves is a costly activity which must therefore be considered as an integral part of the optimisation process. Hence the purpose of this chapter is to develop testable hypotheses concerning the impact of market structure on price flexibility by examining the relationship between search costs, market structure and the price adjustment decision in a rigorous theoretical framework.

The theoretical analysis will be divided into two distinct but complementary parts. The first will be concerned with the comparative statics of adjustment, that is, with the absolute change involved in moving from one equilibrium price to another. The second part will be concerned with the dynamics of price adjustment, i.e. with the optimal rate of price change over time.

Thus, the analysis which follows can be characterised by a "dual-decision" approach whereby the firm first establishes the degree of adjustment which is required in order to restore equilibrium, and then reaches an independent decision as to how much of this price change it should pass on in the current period. The alternative is to develop a dynamic optimisation model in which the magnitude and rate of adjustment are determined simultaneously. However, a recent theoretical study of optimal advertising strategies by Glaister (1974) showed that a fairly general dynamic formulation of the problem posed immense analytical difficulties. Yet a detailed examination of some special cases gave results which were very similar to those obtained from a more conventional comparative statics framework. This would suggest that abandoning the dynamic optimisation technique in favour of the "dual-decision" approach should not affect the substance of our analysis, and whilst this methodology is not entirely without drawbacks, its advantage is that it avoids some of the major analytical complexities.

Section 4.2 of this chapter will be devoted to a detailed examination of search activity and the determinants of its cost. We would justify this in-depth discussion on grounds of the important role given to search in the price adjustment decision.

In section 4.3 we shall develop a comparative statics model of price determination and adjustment. Oligopolistic interdependence will be introduced explicitly through the demand curve and search costs will also be incorporated in the model. In addition we shall examine the influence of risk and uncertainty.

In section 4.4 we shall examine the dynamics of adjustment by means of a partial price adjustment model. The impact of search and the influence of market structure on search costs will be explicitly considered in the model.

Finally, section 4.5 will contain an outline of the hypotheses derived from the theoretical analysis in addition to a few concluding observations.

4.2 Collusion, Information, and Search Costs

The fundamental assumption underlying the analysis in this chapter is that firms recognise the benefits of joint-profit maximisation, although they are not always able to achieve it. The ability of firms to sustain higher prices than those which would prevail if each firm acted independently depends on the degree to which they succeed in co-ordinating their price and output policies.(1) The problem of co-ordination exists because under any non-competitive price structure there is an incentive for each firm to reduce its price unilaterally thereby expanding its sales at the expense of its rivals. This incentive stems from the difference which exists, under a non-competitive price structure, between the firm and industry price elasticities of demand.(2)

The difficulty of monitoring or policing any collusive price structure, whether tacit or overt, depends crucially on the availability of information concerning the prices charged by other firms in the industry. But it should be emphasised that it is the transaction prices which need to be identified, since the list prices which can be easily discovered could be merely the veil behind which secret price reductions may be taking place. The importance of this point was stressed by Stigler (1964), who stated that:

> "In general the policing of price agreements involves an audit of the transaction prices .... Ultimately there is no substitute for obtaining the transactions prices from the buyers."(3)

Thus the acquisition of information necessitates active search, a scanning process by the firm aimed at detecting discrepancies between nominal and transaction prices. This is supported by evidence contained in a recent empirical study which examined in some detail the problems

(1) We shall abstract for the moment from other relevant decision variables, namely advertising and product quality.

(2) See Stigler (1964), pp. 45-46.

(3) Stigler (1964), p. 45.

associated with the search for accurate information on transaction prices.[1] One solution to this problem would be to monitor prices collectively through trade assocations. However, in practice such institutional policing arrangements are seldom effective due to the ease with which the information submitted can be falsified.

The importance of information on prices has also been recognised in the theoretical literature of oligopoly. Nicholson (1972) analysed the behaviour of oligopoly using a game-theoretic approach. One of his conclusions was that the pricing strategy, because it is highly flexible and can be used as a competitive weapon at relatively short notice, is particularly suitable for collusion.[2] However, Nicholson also recognised that the flexibility of the price strategy is conditional upon the availability of information:

> "The view that pricing is a flexible strategy in comparison with other strategies is based on the view that the prices on the market are readily known to the participants in the market. This is not necessarily the case, however.[3]

Before going on to discuss the determinants of search costs it is necessary to consider how the equilibrium <u>level</u> of search activity might be attained. A rational optimisation process would involve two basic relationships; the first between search levels and the associated benefits, and the second between the level and the marginal costs of search. Looking at the benefits of search, it is clear that this activity yields a return to the firm, irrespective of the degree of industry collusion, by enabling it

---

(1) Hague (1971), pp. 122-123.

(2) Thus Nicholson is implying that collusion over advertising and quality changes is less easily achieved.

(3) Nicholson (1972), p. 199.

to optimise its decision variables in relation to the observed behaviour of competitors and thus to obtain maximum profits. Furthermore, since search constitutes a form of policing, it will raise profitability at the industry level by deterring secret price cuts. Regarding the relationship between the marginal returns and the level of search, some evidence on this subject is available from the contribution by Stigler (1961) which was reviewed in the preceding chapter. Although Stigler's analysis is based on the search by consumers for low-price sellers, it is equally applicable in the context of the firm's search for secret price cuts, since the underlying process of search is the same. Stigler's conclusion was that:

> "Whatever the precise distribution of prices, it is certain that increased search will yield diminishing returns ...."(1)

Thus, if the benefits of search for the representative firm are given by the function $B = B(S)$ where S denotes the level of search activity, we would expect it to have the following properties: $B'(S) > 0$, and $B''(S) < 0$. However, the ceteris paribus nature of this functional relationship must be strongly emphasised; for the marginal benefits of search are conditional on the structural and behavioural characteristics of the industry, amongst which the degree of collusion is particularly important. An increase in the degree of collusion will shift the $B'(S)$ schedule so that the marginal benefits of search will now be higher at every level of search activity. This is because a higher degree of collusion implies that greater joint profits can be achieved by the industry if secret price cutting is deterred. Another factor which might be expected to influence the marginal benefits of search

---

(1) Stigler (1961), p. 215. This result is based on the fact that with a uniform distribution of asking prices, the expected minimum price declines at a decreasing rate as the number of units searched increases. This result also applies for other distributions.

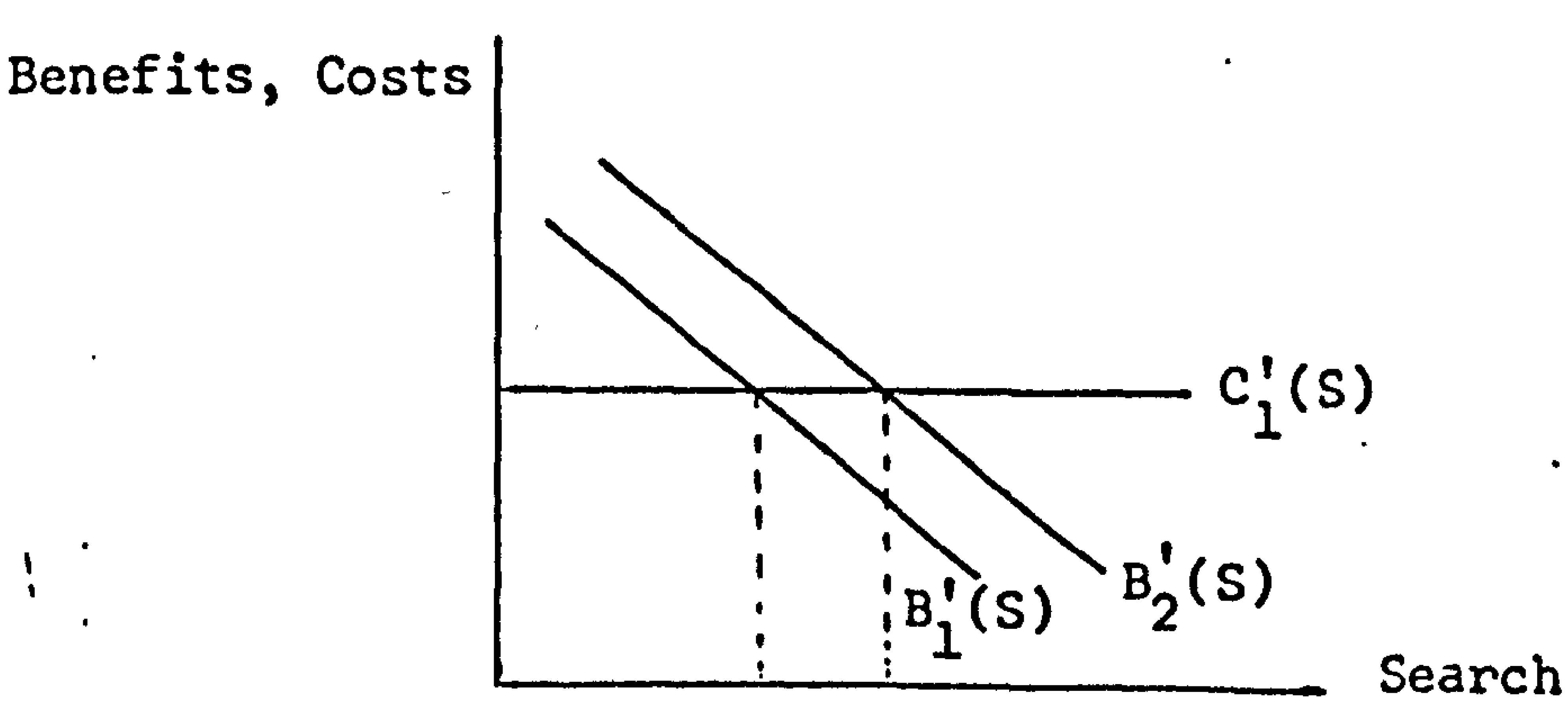
is the lag of rivals' retaliation. Thus, the longer is the time required to adjust prices once secret cuts have been detected, the lower will be the benefits of additional search.

We must now consider the nature of the marginal costs of search function, $C_i'(S)$. What evidence is available on this subject suggests that the costs of search are proportional to the number of units searched, therefore implying constant marginal costs, i.e. $C'(S) > 0$ and $C''(S) = 0$.(1) We shall therefore assume, for purposes of analysis, that the marginal costs of search activity are constant. However, as with the benefits of search $B'(S)$, the marginal cost function $C'(S)$ is conditional on the characteristics of the industry, so that a change in any one of these will cause it to shift. The relationship between these characteristics and marginal search costs will be examined later on.

We can now determine the equilibrium level of search activity for the representative firm.(2) The first order condition for the maximisation of net search benefits requires that the marginal benefits and costs be equal. Such an equilibrium is depicted by the intersection of the $B_1'(S)$ and $C_1'(S)$ schedules in figure 4.1 below:

Figure 4.1

The Equilibrium Level of Search



(1) This relationship was suggested by Stigler (1961).

(2) We are therefore implicitly assuming that collusion over search activity is not possible.

Now consider the effect of an increase in the degree of collusion on the B'(S) and C'(S) schedules. Taking B'(S) first, it has already been argued that this schedule will shift to the right as illustrated by B'(S) in the figure. But what will the effect be on the C'(S) schedule? It could be argued that it is easier to detect secret price cutting when the degree of collusion is high and output considerably restricted than when it is relatively low and output is near the competitive level. This is based on the notion that price cutting can be inferred from movements in sales levels, or as suggested by Stigler (1964), by comparing the expected and observed variance of sales. However, Scherer, (1970) was critical of this assumption on the grounds that it implies a "sophisticated notion of randomness" on the part of firms which is scarcely tenable.[(1)]

On the other hand it could be argued that at high levels of collusion, mindful of the fact that the detection of secret price cuts is made easier through their effect on sales, firms may attempt to offset this tendency by making greater efforts to conceal transactions prices. One way of doing this is by increasing the degree of product differentiation. Hence it is difficult to specify the relationship between marginal search costs and the degree of collusion <u>a priori</u>, and consequently we shall assume that C'(S) remains invariant with respect to the degree of collusion.

Thus, an increase in the degree of collusion will shift the B'(S) schedule to the right whilst not influencing C'(S). As can be seen from figure 4.1, the equilibrium level of search activity will therefore rise, and since marginal search costs are assumed constant, total expenditure on search activity will also increase. In conclusion, this implies that the total costs of search will be positively related to the degree of collusion.

---

(1) Scherer (1970), p. 208.

Before examining the structural characteristics which influence search costs we need to say something about the actual search process. Collecting information involves scanning in order to detect discrepancies between the list and transaction prices, and there are two main ways in which firms can do this. The first involves finding out the transaction prices directly from buyers, but as was argued by Hague (1971), this constitutes an open invitation to bluff. The other method is for firms to pose as potential buyers, but this is also fraught with difficulties, particularly since there is a need to consider such factors as differences in product quality, the cost and length of deliveries, differences in the liability accepted by the seller for his product, and the type of credit facilities offered. By far the most important are differences in quality.

In an earlier chapter we referred to the findings by Cowling and Cubbin (1971) which suggested that quality changes can be used to conceal price reductions. Thus, by making price cutting more difficult to detect, quality changes lengthen the process of search and thereby reduce the speed with which rivals can retaliate. This implies that undercutting prices through quality changes is an effective competitive strategy, particularly since:

> "The longer the adverse consequences of rival retaliation can be forestalled, the more attractive undercutting the accepted price structure becomes."[(1)]

Given that differences in quality increase the complexity of search, we would expect marginal search costs to be positively related to the degree of product differentiation in an industry.

Another important determinant of search costs is the frequency of transactions, i.e. the prevalence of one-off contracts. Where buying is infrequent and involves competitive tendering, the discovery of transaction

(1) Scherer (1970), p. 208.

prices may not take place until it is "too late", that is, until the contract has been awarded to a competitor. Under these conditions search activity could become highly intractable and this may account for the observed instability of oligopolies in industries where transactions are "lumpy" and therefore infrequent.(1) Since this pattern of transactions is more closely associated with capital goods industries than with consumer goods industries, we would expect marginal search costs to be higher in the former than in the latter, *ceteris paribus*.

As regards the impact of the number and size distribution of sellers on search costs, we shall begin the discussion by considering Stigler's (1964) analysis of the factors which influence the detection of secret price cutting. Stigler's approach was based on the premise that secret price cuts could be identified from discrepancies between the observed and expected variance of sales. If the number of new customers is given by n, and the probability of attracting a customer is proportional to the firm's share of total industry output (x), then the variance of the firm's share of sales to new customers is given as x(1-x). Summing over all firms in the industry we get:

$$C = n\Sigma x(1-x) = n(1-\Sigma x^2) = n(1-H)$$

where $H = \Sigma x^2$ is the Herfindahl index of concentration. Thus as H rises towards its upper bound of unity and the variance of sales falls, so the detection of secret price reductions becomes progressively easier. This implies that the costs of search will fall as industrial concentration, measured by the Herfindahl index, rises.

Stigler extended the analysis by taking into account the variance of sales to existing consumers, but the results remained essentially the

(1) Both Scherer (1970) and Nicholson (1972) stressed the importance of this point.

same. Yet the difficulty with this approach, as has already been mentioned above, lies in the notion that firms can infer the extent of price cutting from differences between the observed and expected variance of sales. Furthermore, there remains the question concerning the source of the price cuts which cannot be discovered in the manner suggested above.

Search must therefore be concentrated on prices. What relationship would we then expect between search costs and seller market structure? It has been suggested by Stigler (1961) that search costs will rise in proportion to the number of units sampled, i.e. the number of firms in the industry.(1) On the other hand, Scherer (1970) has shown that the number of information channels or links between firms rises more than proportionately to the number of firms in the industry. Thus in the context of tacit or overt communication between firms, the number of information channels is related to the number of firms by the combinatorial expression $N(N-1)/2$, so that with four firms the number of channels is six, with six it rises to fifteen and so on.(2) Therefore, taken together these propositions suggest that marginal search costs are an increasing function of the number of firms in the industry, <u>ceteris paribus</u>.

However, we must also consider the size distribution of sellers in the industry, not only their absolute number. The search for price information is likely to be weighted, for each firm undertaking search activity, by the estimated impact on sales of the potential price reductions of its competitors. Since any firm which is engaged in secret price cutting must have the capacity to meet the anticipated

(1) Stigler (1961), p. 216.

(2) See Scherer (1970), p. 184.

increase in demand, a price cut by a firm with a large market share will have a greater weight than a price cut made by a relatively small firm with an insignificant market share. Thus the impact of secret price cuts will be related to the existing market shares of the firm responsible for them. We would therefore hypothesise that search costs are more appropriately related to the level of industrial concentration, as measured by the Herfindahl index or the concentration ratio, than to the absolute number of firms in the industry.

Finally, we need to consider the effect of the number and size distribution of buyers. On the one hand, Stigler (1964) demonstrated that the probability of a rival learning about secret price cuts rises rapidly with the number of buyers in the industry. But on the other hand, any firm engaged in search activity will need to discover the extent and the source of price reductions and, consequently, the difficulties of search will increase with the number of buyers. Given these two offsetting tendencies, the impact of buyer concentration on marginal search costs cannot be determined with certainty.

To conclude, it was suggested in this section that collusion can only be sustained with search for information on transaction prices. We also examined the optimisation process whereby the equilibrium level of search is attained and the structural factors which influence the costs of search. The impact of search costs on price adjustment will be examined in the next two sections of this chapter.

4.3 The Comparative Statics of Price Adjustment

In this section we shall develop a static model of price determination and adjustment for a representative firm, i. Oligopolistic interdependence will be introduced explicitly through the firm's demand curve, and it will be assumed that, like all other firms in the industry, firm i is an aggressive profit maximiser. Inventory problems will be ignored and it will also be assumed that firms are price-quoters; they supply whatever is demanded at the equilibrium price. In addition, it will be assumed that the products of different firms within the same industry are slightly differentiated. Finally, for the sake of analytical convenience linear cost and demand functions will be used and the resulting implications will be assessed at the end of this section.

The demand curve facing firm i is defined as:

$$(1) \qquad Q_i = a + \beta_1 P_i + \mu \bar{P}_j + z \qquad \beta_1 < 0, \quad \mu > 0, \; /\mu/ < /\beta_1/$$

where Q denotes quantity demanded, P denotes price, $\bar{P}_j$ is the average price of all firms in the industry other than i, and z is a random variable with zero mean and variance σ_z^2. This last variable captures such influences as the random switching of consumers between sellers and thus introduces uncertainty into the model. The restriction $/\mu/ < /\beta_1/$ is imposed in order to ensure that firm i's demand curve retains its negative slope when collusion is perfect and all firms charge the same price. Thus if $P_i = \bar{P}_j$ and if market shares are fixed, firm i will face a demand curve with the same slope as the industry demand curve, $(\beta_1 + \mu)$.

Firm i's cost function is defined as:

$$(2) \qquad C_i = \beta_o + \beta_2 Q_i \qquad \beta_2 > 0$$

To specify the search expenditure function along the lines suggested in the preceding section it is necessary to have some measure of the degree of collusion as perceived by the representative firm under consideration. Two related measures suggest themselves, the first being the average price charged by firm i's competitors, and the second being an estimate of the average price-cost margin.(1)

Our choice between these alternative measures was largely influenced by the fact that the equilibrium price-cost margins is determined not only by the degree of collusion but also by other factors which are not associated with inter-firm co-operation. Among the most important of these is the price elasticity of demand. Thus even if there was no collusion in the industry,as in the Cournot case, the price-cost margin would vary with changes in the elasticity of demand and the number of firms in the industry. Yet the degree of collusion would be zero and invariable by assumption. For this reason we considered the price level to be a more appropriate measure of collusion although, as will become clear below, using the price-cost margin as a proxy for collusion did not affect the substance of our results.

However, two central aspects of the proposed index of collusion require clarification. First, it is important to distinguish between the nominal and the effective degree of collusion. Firms observe the list prices of their competitors and use this information as the basis for expectations about effective collusion. If expectations are revised after search, it is likely that list prices will ultimately fall to reflect transaction prices once more, since they cease to be the veil behind which secret price cutting can take place. This would constitute a collusion breakdown. On the other hand an equilibrium will be achieved when nominal and effective collusion, as perceived by all firms, are equal and search activity is maintained at constant levels.

The other important issue concerns the fact that the absolute price level as measured by $\bar{P}_j$ will change over time without necessarily implying a change in the conduct of firms. We therefore need to define

(1) This would be an approximation to the Lerner index of monopoly power.

the index of collusion as a price relative, that is, in terms of $\bar{P}_j$ divided by a given base price. The latter may be specified as firm i's estimate of the long-run industry equilibrium price in the total absence of collusion and with the existing number of firms. However, since we shall assume that this estimate does not change in the short-run and hence with the parameters in our model, we shall specify the search expenditure function simply in terms of $\bar{P}_j$ where this represents an index of the average competitors' price relative to a predetermined reference level. Thus the search expenditure function is given as:

$$(3) \qquad C_{si} = c_s(\bar{P}_j, CR) \qquad \frac{\partial C_{si}}{\partial \bar{P}_j} > 0$$

where CR stands for seller concentration.(1) Equation (3) implies that search expenditure never falls to zero, not even in the absence of price co-ordination when each firm sets its price independently of its rivals, since $\bar{P}_j > 0$. This characteristic of the expenditure on search will be explained later in the context of the determination of the equilibrium price P_i^*. Combining equations (1), (2) and (3), firm i's profit function becomes:

$$(4) \qquad \pi_i = P_iQ_i - C_i - C_{si}$$

$$= (P_i - \beta_2)(a + \beta_1P_i + \mu\bar{P}_j + z) - \beta_o - C_{si}$$

It will be assumed initially that the firm is risk-neutral and therefore seeks to maximise expected profit $E(\pi_i)$. The first order condition for this maximum is given by:

$$\frac{dE(\pi_i)}{dP_i} = a + 2\beta_1P_i + \mu\bar{P}_j + P_i\mu\frac{d\bar{P}_j}{dP_i} - \beta_2\beta_1 - \beta_2\mu\frac{d\bar{P}_j}{dP_i} - \frac{\partial C_{si}}{\partial \bar{P}_j}\frac{d\bar{P}_j}{dP_i} = 0$$

---

(1) It should be pointed out that C_{si} refers to the equilibrium level of search expenditure. The level of search activity and hence search expenditure is endogenous in this analysis and its determination was discussed at length in the preceding section. The method is conceptually equivalent to maximising a profit function similar to equation (4) but where C_{si} does not represent an optimum. Equilibrium search expenditure is then derived from the first order conditions.

Expression $d\bar{P}_j/dP_i$ which will be denoted by α shows the extent to which rivals will follow a price change which is initiated by firm i.[1] If $\alpha = 0$ then rivals do not respond to firm i's pricing decision, which implies that the degree of collusion remains unchanged. However, if α is greater than zero then, like every one of its competitors, firm i will need to consider the effect of its own pricing policy on the degree of collusion. The expression $\partial C_{si}/\partial \bar{P}_j$, which defines marginal search expenditure with respect to collusion, will be denoted by c_s'.

Solving for the equilibrium price P_i^*, we obtain

$$(5) \qquad P_i^* = \frac{\beta_2(\beta_1 + \mu\alpha) - a - \mu\bar{P}_j + c_s'\alpha}{2\beta_1 + \mu\alpha}$$

It can be seen that since the denominator is negative the equilibrium price will be a rising function of marginal costs, β_2. Furthermore, if $\alpha = 0$ then the equilibrium price is set in Cournot fashion, with firm interdependence essentially ignored, and P_i^* determined on the assumption that rivals will not respond to it.[2] In this case marginal search expenditure will have no influence on the equilibrium price since it does not appear in expression (5). However, since the average price of competitors, $\bar{P}_j$, is still positive, search expenditure will also be positive. Hence in the Cournot case, search expenditure is essentially fixed and has no influence on the equilibrium price. We would explain this by suggesting

(1) The term α is a very close approximation to what Cubbin (1974) has called the degree of "apparent collusion". It defines an expectation on the part of the firm concerning rivals' response to its own price change; an expectation which is only realised in equilibrium.

(2) This would essentially represent Cournot behaviour, although it would be strictly correct to say that Bertrand-type behaviour is implied since it is price, not quantity, which is the decision variable. The distinction between the Bertrand and Cournot models is given in Chamberlin (1962), Chapter 3.

that firms will engage in some search activity, however little, even if they are acting independently. There are two reasons for this. First, even if pricing behaviour suggests no collusion, these expectations need continuous confirmation, given that firms recognise the benefits of collusion. Second, firms will search for information about the dynamics of prices, that is, about the rate at which competitors increase or decrease their prices. This aspect of search activity will be discussed further in the next section.

If $\alpha > 0$ and marginal search expenditure is given by $c_s' > 0$, then the firm will need to consider the additions to search expenditure when determining the equilibrium price P_i^*. Thus there are marginal costs as well as benefits to increasing collusion.(1) Furthermore, even if all firms in the industry set price in parallel fashion ($\alpha = 1$), the highest joint profit maximising price attainable will still be lower than the monopoly price on account of the presence of marginal search expenditure Whilst the monopolist has no search costs, a group of firms acting as a monopolist has to bear the costs of policing through search.

In order to determine the impact of search expenditure on price adjustment, we shall evaluate the derivatives of the equilibrium price P_i^*, with respect to the cost and demand parameters, β_2 and β_1 respectively. Evaluating the degree of adjustment to a change in the demand parameter β_1, we obtain:

$$(6) \qquad \frac{dP_i^*}{d\beta_1} = \frac{2(a + \mu\bar{P}_j) - \alpha(\mu\beta_2 + 2c_s')}{(2\beta_1 + \mu\alpha)^2}$$

It should be noted that since β_1 is negative, an increase in the absolute

---

(1) The marginal benefits to firm i enter through the positive effect of a higher α on the equilibrium price.

value of β_1 implies a higher elasticity of demand and consequently a reduction in the equilibrium price P_i^*. Conversely, when β_1 falls in absolute value, the equilibrium price will rise. Furthermore, since the denominator is positive and c_s' appears with a negative sign, the degree of price adjustment, whether upward or downward, is attenuated by the presence of marginal search expenditure.

Turning to the marginal cost parameter, the derivative of P_i^* with respect to β_2 is equal to:

$$(7) \qquad \frac{dP_i^*}{d\beta_2} = \frac{\beta_1 + \mu\alpha}{2\beta_1 + \mu\alpha}$$

It is clear from expression (7) that expenditure on search has no influence on the adjustment of P_i^* to changes in β_2. The asymmetry in the impact of search on price adjustments to changes in marginal cost and demand is important, and the underlying rationale needs to be elucidated.(1)

A change in β_1 implies a different price elasticity of demand <u>ceteris paribus</u>, and more specifically, that the response of quantity demanded to a price adjustment has changed. Expression (5) shows that the impact of search expenditure on the equilibrium price, P_i^*, is weighted by the term $2\beta_1$ which appears in the denominator. This means that when β_1 is large in absolute value the impact of marginal search expenditure ($c_s'\alpha$) on the equilibrium price will be correspondingly small. This result is intuitively plausible since a large (negative)

---

(1) If search expenditure was related to the price-cost margin as given by $\bar{P}_j/\beta_2$, the equilibrium price for firm i would be:

$$P_i^* = \frac{\beta_2(\beta_1 + \mu\alpha) - a - \mu\bar{P}_j + (c_s'\alpha/\beta_2)}{2\beta_1 + \mu\alpha}$$

It is easily verified that in this case the asymmetry still holds.

value of β_1 implies that, for a given value of μ, the impact of firm i's price adjustments on demand (Q_i) will outweigh the corresponding influence of price adjustments by competitors. Hence, when the consequences of ignoring the effect of rivals' pricing strategies are relatively minor, the equilibrium level of search and hence marginal search expenditure will be generally low. In these circumstances it will have an insignificant effect on the equilibrium price.

Thus a fall in β_1, which implies a steeper demand curve, will lead to greater expenditure on search through the greater impact of oligopolistic interdependence on firm i's demand. The same reasoning applies for a rise in the value of the parameters α and μ, since this will also increase the influence of rivals' pricing decisions. However, it is interesting to note that search expenditure does not enter into the price adjustment decision following changes in the intercept (a), given that:

$$(8) \qquad \frac{dP_i^*}{da} = - \frac{1}{2\beta_1 + \mu\alpha}$$

Yet the most general type of change in demand is likely to involve both a change in the slope and the intercept of the demand curve, and in that case search expenditure would remain an integral part of the price adjustment decision. Furthermore, the significance of the postulated change in the slope is borne out by the celebrated kinked-demand curve hypothesis, put forward by Sweezy (1939), concerning the effect on the slope of the firm's demand curve of different assumptions about inter-firm behaviour. Finally, since changes in the marginal cost parameter β_2 are unrelated to the influence of oligopolistic interdependence, search expenditure will have no bearing on price adjustments which follow in their wake.

Before assessing and qualifying these results we shall briefly examine the influence of risk aversion on the adjustment process within the framework already developed. We shall introduce risk aversion into the model by using the well tried mean-variance approach.(1) Thus firm i will be assumed to maximise an objective function ϕ_i which is defined as:

$$\text{(9)} \qquad \phi_i = E(\pi_i) - \delta \mathrm{Var}(\pi_i)$$

where $\mathrm{Var}(\pi_i)$ is the variance of profit and δ is a coefficient of risk aversion reflecting the extent to which firm i is unwilling to accept risk. Thus δ is preceded by a negative sign, and it is approximately equal to the coefficient of absolute risk aversion (R_A) which was defined in the previous chapter. The variance of π is defined as:

$$\text{(10)} \qquad \mathrm{Var}(\pi) = E(\pi - E(\pi))(\pi - E(\pi))$$

Substituting for π_i we obtain:

$$\text{(11)} \quad \mathrm{Var}(\pi_i) = (P_i - \beta_2)^2 \sigma_z^2 = (P_i^2 - 2\beta_2 P_i + \beta_2^2)\sigma_z^2$$

Substituting equation (11) for $\mathrm{Var}(\pi_i)$ in equation (9), maximising ϕ_i with respect to P_i and solving for the equilibrium price gives:

$$\text{(12)} \qquad P_i' = \frac{\beta_2(\beta_1 + \mu\alpha - 2\delta\sigma_z^2) - a - \mu\bar{P}_j + c_s'\alpha}{2(\beta_1 - \delta\sigma_z^2) + \mu\alpha}$$

It can be seen that expression (12) is similar to expression (5), the only difference being the appearance of the term $\delta\sigma_z^2$ in the numerator and denominator of (12). Taking the derivative of P_i' with respect to δ it is immediately apparent that risk aversion will raise the equilibrium price relative to its level under risk neutrality.(2)

---

(1) It has been shown by Pratt (1964) that maximising an objective function defined in terms of the mean and variance of profit is approximately equivalent to maximising the utility of profit.

(2) This is consistent with the findings concerning risk aversion which were reviewed in the preceding chapter.

As before, we evaluate the derivative of P_i' with respect to the demand coefficient β_1 for the risk averter:

$$(13) \qquad \frac{dP_i'}{d\beta_1} = \frac{\beta_2(2\delta\sigma_z^2 - \mu\alpha) + 2a + 2\mu\bar{P}_j - 2(c_s'\alpha)}{(2\beta_1 - 2\delta\sigma_z^2 + \mu\alpha)^2}$$

As with expression (6), search expenditure appears with a negative sign in (13) thus exerting an attenuating influence on the degree of adjustment. Evaluating changes in the cost parameter, β_2:

$$(14) \qquad \frac{dP_i'}{d\beta_2} = \frac{\beta_1 + \mu\alpha - 2\delta\sigma_z^2}{2\beta_1 + \mu\alpha - 2\delta\sigma_z^2}$$

Expression (14) is similar to (7), but in the former the term $2\delta\sigma_z^2$ appears both in the numerator and the denominator. The effect of this is to raise the degree of price adjustment of the risk averse firm relative to the risk neutral firm, but this is hardly surprising since the former has a higher equilibrium price. Furthermore, since search expenditure does not appear in expression (14) it can be seen that the asymmetry of price adjustment to changes in cost and demand is not affected by the introduction of risk aversion into the model.

We must now qualify these results and examine the assumptions on which they are based. First, there is the assumption of linear cost and demand functions, and it is clear that the analysis would be considerably more complex, and the outcome less clear-cut, if this assumption were relinquished. In the context of the demand curve, however, linearity may be a tenable first approximation provided we are prepared to restrict the analysis to fairly small changes in price. As regards marginal costs of production, there exists considerable empirical evidence which suggests that they are constant over the normal range of output.(1)

(1) See Scherer (1970), p. 77.

It must also be stressed that the comparative statics analysis, by its very nature, abstracted from considerations of time. Yet in the context of search costs it is possible that time may be of some importance. For example, in the short-run search costs may be high because there has been little opportunity to observe the behaviour of rivals. As time goes on, however, information may become available at small cost through the cumulative observation of firms' behaviour. The possibility that the costs of search may vary with the time available for search activity has been noted by Alchian (1970):

> "Dissemination and acquisition (i.e. the production) of information conforms to the ordinary laws of production: faster dissemination, or acquisition costs more."(1)

Thus, although in our analysis we did not consider the question of time, it could have a significant influence on the costs of search which we would expect, on a priori grounds, to be greater in the short-run than in the long-run. This issue will not be pursued further, but it should be borne in mind in the context of the empirical findings reported in Chapter 6.

In conclusion, whilst not particularly general, our comparative statics analysis would suggest that within a plausible scenario price adjustments following changes in demand could be attenuated relative to those occasioned by changes in marginal cost. This result is due to the influence of search costs on the adjustment decision. The consequential implications for quantity adjustments will be discussed in the concluding section of this chapter.

---

(1) Alchian in Phelps ed. (1970), p. 29.

4.4 The Dynamics of Price Adjustment

The dual decision approach implies that when the firm has established the magnitude of the price change required to restore equilibrium, it faces another and no less important decision concerning the optimal rate of adjustment.(1) It achieves this by determining how much of the desired price change it should pass on in the current period, a decision which is necessary because there are costs associated with an instantaneous price adjustment. At the end of this section we shall have more to say about the implications of this methodology.

The basic approach adopted here owes its origin to Griliches (1967). It consists of a partial price adjustment model in which the costs of adjustment are a crucial determinant of the adjustment coefficient, λ - the latter representing the proportion of the desired price change which should be passed on in the current period. Our point of departure is to identify the variables which influence the adjustment process. The first is the degree of disequilibrium which is measured by the difference between the actual and the equilibrium price in the current period, $P_t - P_t^*$. The desired rate of adjustment is determined by the extent of disequilibrium and, while it persists, the firm's objective function will not be maximised and therefore some profits will be sacrificed. The other relevant decision variable is the actual rate of price change, measured by the difference between the price in the current and the previous period, $P_t - P_{t-1}$ or ΔP_t. As will be argued below, the greater is this rate of price change, the higher will be the associated costs of adjustment.

---

(1) In order to avoid confusion between optimal price adjustment and changes in the optimal price, we will refer to the latter as changes in the equilibrium price. All references to an optimum will be in connection with rates of change.

In what follows it will be assumed that these profit losses and adjustment costs are quadratic functions of the deviations of P_t^* from P_t and the absolute rate of change (ΔP_t) respectively. This assumption ensures that the profit losses and adjustment costs will be positive and symmetric about the relevant variables, and that they will rise at an increasing rate. We would therefore suggest that as an approximation to the actual costs of adjustment this assumption is not unduly contentious. The functional specification to which we refer is as follows:

$$(15) \qquad C = f(P_t - P_t^*)^2 + g(\Delta P_t)^2 \qquad f' > 0, \quad g' > 0$$

The first part of equation (15) represents the profits forgone by adjusting the price at anything less than the full amount required to restore equilibrium. These losses exert pressure on the firm to pass on the entire price change in the current period, i.e. to adjust prices instantaneously. It is not clear whether the pressure for an instantaneous adjustment is greater in monopolistic or competitive industries, and we must therefore conclude that very little can be said *a priori* concerning the relationship between profits forgone due to delayed adjustment and market structure.

Turning to the costs of adjustment *per se*, as defined by the second term of equation (15), it seems that traditionally these costs were purported to arise from the need to disseminate information about forthcoming price changes. This essentially involves sending out new price lists, and the very nature of these costs suggests that they are fixed: they do not vary with the degree of adjustment.(1) However, our basic premise is that the costs of adjustment will be an increasing function of ΔP_t, with market structure playing a central role. The underlying rationale is based on the existence of two types of adjustment costs. The first stems from the

(1) Except insofar as the frequency of adjustment may change. This question will be examined at the end of this section.

required information concerning the adjustment behaviour of rivals. For when the desired rate of price adjustment is established and the new equilibrium price is known, the firm then faces the problem of co-ordinating its price changes with those of its competitors. This is a problem of dynamic oligopoly and its importance is related to the fact that there are risks in disregarding the average rate of adjustment in the industry. Suppose one firm's partial adjustment coefficient is consistently higher than the industry norm; consumers will eventually learn that in times of rising costs the firm's price will be higher than the industry average, with a resulting loss of demand.(1) It is therefore crucial for firms to obtain information on the current and past adjustment rates of their competitors. But, as was indicated in an earlier section of this chapter, the costs of gathering this information will be inversely related to the degree of industrial concentration. Thus it is partly through its impact on the costs of search that market structure influences the rate of price adjustment.

Market structure will also affect the costs of adjustment through its impact on the losses associated with deviations from the average industry rate of change. We would hypothesise these losses to be inversely related to concentration, assuming that product differentiation tends to increase with the level of industrial concentration. For in this case, we would expect the cross-price elasticities of demand to be lower in concentrated industries, and the demand shifts arising from differential adjustment rates to be correspondingly smaller. As regards the relationship between market structure and product differentiation, Cowling et al. (1975) found strong evidence that advertising levels are positively related to concentration,(2) and this suggests a similar relationship for

---

(1) With falling prices the risks stem from the fact that an instantaneous downward price adjustment might be mistaken for predatory pricing behaviour leading to an eventual breakdown of collusion.

(2) The estimated relationship had an interior maximum.

product differentiation.

In replacing equation (15) by a more explicit functional form we substitute $\Delta P_t - (\Delta P_t)^*$ for $P_t - P_t^*$, where $(\Delta P_t)^*$ represents the desired rate of adjustment, given that these two expressions are equivalent:(1)

$$(16) \qquad C = a(\Delta P_t - (\Delta P_t)^*)^2 + (b/CR)(\Delta P_t)^2$$

where a is the coefficient proportional to the profits lost through delayed adjustment and b/CR represents the costs of adjustment which are inversely related to industrial concentration (denoted by CR).

Assuming that the firm minimises adjustment costs in each period, we differentiate equation (16) with respect to ΔP_t and set the derivative equal to zero.

$$\frac{dC}{d(\Delta P_t)} = 2a(\Delta P_t - (\Delta P_t)^*) + 2(b/CR)(\Delta P_t) = 0$$

This can be re-arranged to give:

$$\Delta P_t = \lambda(\Delta P_t)^* \qquad \text{where } \lambda = \frac{a}{a + b/CR} \quad \text{or}$$

$$(17) \qquad \Delta P_t = \lambda(P_t^* - P_{t-1})$$

Thus the optimal rate of adjustment is some fraction of the desired rate $(P_t^* - P_{t-1})$ in the current period. The partial adjustment coefficient, λ, which defines this fraction has an upper bound of unity and a lower bound of zero, and its actual size will depend on the relative magnitude of the parameters in the model. For example, in the case of a monopolist the costs of adjustment and hence the b coefficient would be reduced to zero

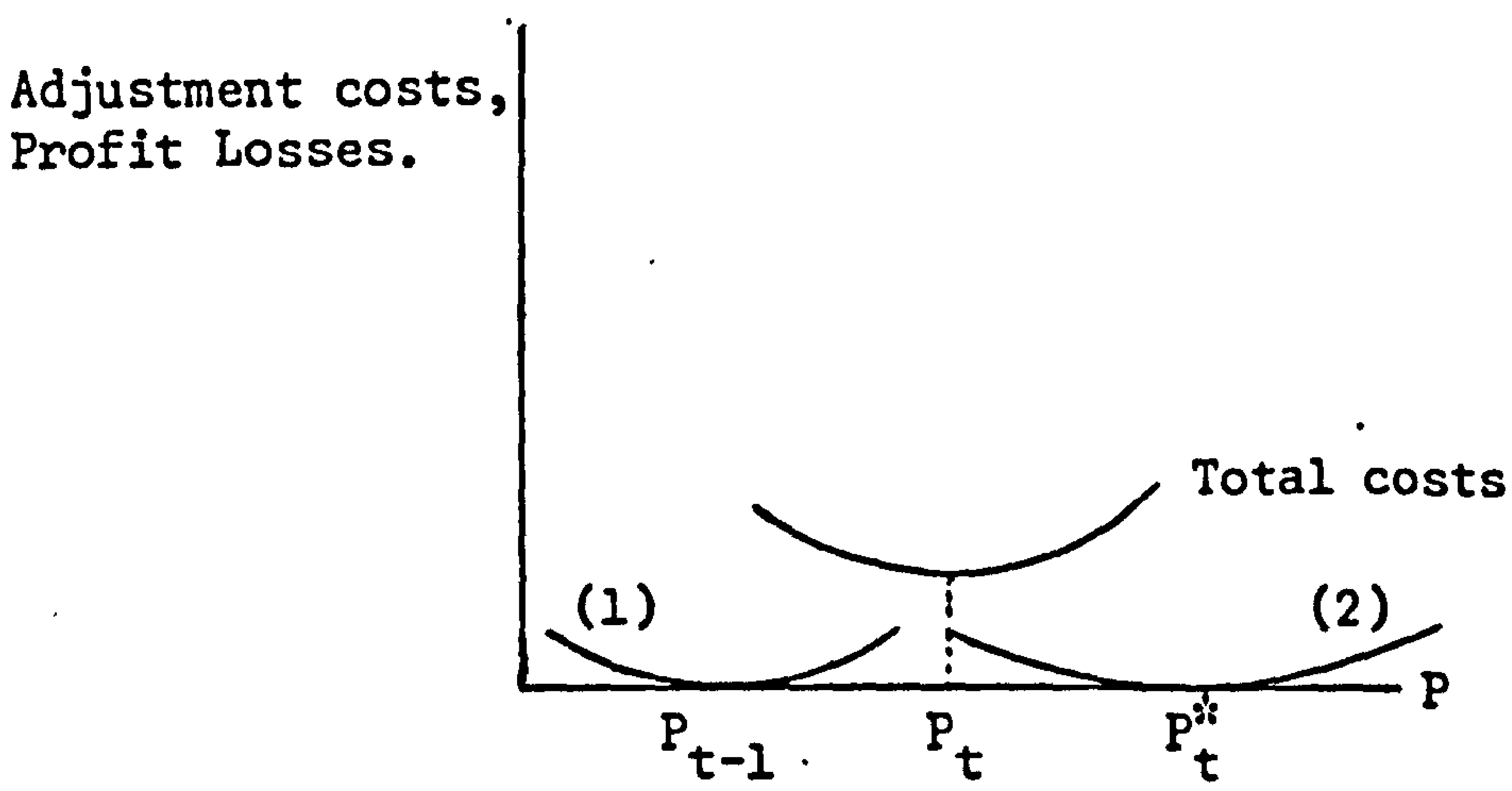
(1) $(\Delta P_t)^*$ is defined as $P_t^* - P_{t-1}^*$ if the firm was previously in equilibrium and $P_t^* - P_{t-1}$ otherwise. Therefore in both cases $(\Delta P_t)^* = P_t^* - P_{t-1}$ and hence $\Delta P_t - (\Delta P_t)^* = P_t - P_{t-1} - P_t^* + P_{t-1} = P_t - P_t^*$.

and this would effectively raise the partial adjustment coefficient to unity ($\lambda = a/a$).[1] However, with more than one firm in the industry there will be non-zero adjustment costs, and consequently the adjustment coefficient will be lower than its upper bound.

The relationships implied by the model can be best illustrated by means of a diagram. In figure 4.2 adjustment costs and profit losses are measured along the vertical axis and price along the horizontal axis. Three separate curves are depicted in the figure. The first, which is at a minimum when $P_t = P_t^*$, represents the profits forgone while being in disequilibrium. The other curve, which is at a minimum when $P_t = P_{t-1}$, defines the costs of adjustment <u>per se</u>. Thus if prices do not change from one period to another there will be no adjustment costs. The total costs curve is the vertical summation of the other two just described.

<u>Figure 4.2</u>

<u>The Optimal Rate of Price Adjustment</u>



Notes: (1) Adjustment costs curve
(2) Profit Loss curve

---

(1) In this situation the only costs are those associated with the deviation from the desired rate of adjustment, and therefore the optimal rate will be an instantaneous one.

The optimisation process which is implied in figure 4.2 can now be elucidated. In the situation depicted the current price needs to be adjusted upwards, since P_t^* is greater than P_{t-1}. An instantaneous increase to P_t^* would reduce the profit losses to zero, but would raise the costs of adjustment to such a level that total costs will not be at a minimum. On the other hand, if the current price is kept at the same level as in the previous period, adjustment costs would then fall to zero but total costs, once again, will not be minimised by this strategy.

The first order condition for a minimum requires that the gradient of the two functions which together make up total costs, i.e. the adjustment cost and profit loss functions, should be equal in absolute value. As this implies, at the point where total costs are minimised the sum of the gradients of the two schedules will be equal to zero since, as illustrated in the figure, in the range between P_{t-1} and P_t^* their gradients have opposite signs.

The extent to which the optimal rate of adjustment approaches the desired rate will consequently depend on the slope of the adjustment cost function relative to the slope of the profit loss function. When adjustment costs rise fairly moderately away from P_{t-1}, the minimum of the total cost schedule will lie close to the equilibrium price, P_t^*. This result is intuitively plausible. It suggests that in industries where concentration is high, adjustment costs will be correspondingly low and hence the optimal adjustment rate will lie close to the desired rate. This in turn implies that the partial adjustment coefficient will be close to unity.

Thus far the dynamic analysis has focused primarily on the influence of market structure, and it may seem that other potentially important factors have been neglected. For example, it could be argued that the rate of adjustment may be influenced by the underlying cause of the price change, that is, whether cost or demand conditions are responsible for disequilibrium.

However, this distinction is not relevant in the context of the "dual decision" approach since it implies that the cost and demand parameters jointly determine the equilibrium price, whilst its optimal rate of change is established by reference to the costs of adjustment.

Yet another factor which needs to be considered is the role of inflationary expectations. These may exert a particularly strong influence in times of high inflation when, fearing a continued rise in the inflation rate, firms may attempt to close the gap between rising costs and prices. Although inflationary expectations have come to be considered as a significant factor in the behaviour of prices, there is no evidence to suggest that they are systematically related to industrial concentration. Consequently the omission of this factor from the theoretical and empirical analysis should have no bearing on the results.(1)

Finally, we must also consider the possibility that quality changes may be substituted for price changes thereby influencing the observed rate of adjustment. This would not constitute a problem if quality-adjusted price data were available, but unfortunately this was not the case. However, what little evidence there is on this subject suggests that quality changes may be a characteristic of concentrated industries,(2) and thus we would expect these industries to be more likely to slow down the observed rate of adjustment by means of quality changes. Therefore, since we hypothesised a positive association between concentration and the rate of adjustment, any potential bias in the empirical analysis resulting from the use of unadjusted price data would run counter to the postulated relationship, and consequently the validity of the results need not come under question.

---

(1) In particular, we do not expect the bias associated with an omitted variable in the regression analysis.

(2) See Cowling and Cubbin (1971).

We conclude this section with one qualification. Setting up the adjustment problem in terms of discrete price changes in each period emphasises the "how much" question to the detriment of the "how often" question which, it could be argued, is equally important but was not considered in this analysis. However, in the context of the period spanned by the empirical tests (1963-1974), we would suggest that the rate of inflation during this time was sufficiently high for the losses resulting from delayed adjustment to be large relative to the purely administrative costs of adjustment. If this is accepted, then it is not unreasonable to concentrate attention on the "how much" decision, which is what has been done here.

4.5 Conclusions

In this chapter we attempted to analyse the price adjustment decision in a rigorous theoretical framework. The principle feature of this analysis consisted of giving explicit recognition to the role played by search in the price adjustment process. The importance of search stems from the limited information industrial setting within which price adjustments actually take place, and the impact of market structure on the latter arises through its influence on the costs of search.

The comparative statics analysis indicated that there may be an asymmetry of price adjustments to changes in marginal costs and changes in demand; an asymmetry which was due to the unequal incidence of search costs. The hypothesis which is based on this result can be stated as follows: price adjustments in response to short-run changes in demand may be attenuated relative to those adjustments which take place following changes in costs.

However, this hypothesis must be qualified on account of one important omission. It concerns the fact that, in the comparative statics analysis, we did not consider the costs associated with quantity adjustments. As with redundancy payments in times of recession, the costs of output adjustments can be significant and, therefore, it must be accepted that by emphasising the costs of search associated with price adjustments and neglecting the costs of output adjustments our results would be biased in favour of the latter. Nevertheless, we would argue that the effect of this omission on the analysis is much reduced by the mitigating influence of two factors. First, quantity adjustments have the advantage of being less easily detected by competitors than price adjustments and therefore may be resorted to when firms wish to avoid disturbing the existing price structure. Second, some of the costs of output adjustments, such as unemployment benefits, are borne by the economy as a whole rather than by the firm which causes them.

If it is supported by the empirical evidence, this hypothesis could have implications for short-run and cyclical fluctuations of economic activity. This is because the attenuation of price adjustments to demand changes in relation to what they would otherwise be under a regime of perfect price flexibility, implies correspondingly larger output adjustments. This possibility has been considered in the disequilibrium literature discussed in chapter 2 [(1)] and the implications, particularly for downturns in economic activity, have been emphasised.

The dynamic analysis was concerned with the determination of the optimal rate of price adjustment over time. The impact of market structure on the optimal rate arose largely through its influence on search costs. From this analysis we derived the hypothesis that industrial concentration will be positively related to the rate of price adjustment. This hypothesis has clear implications for the link, which has often been

---

(1) Particularly by Leijonhufvud (1968) and Hines (1971).

assumed to exist, between industrial concentration and inflation: In terms of our own results the suggestion is that, by speeding up the adjustment process, concentration could aggravate the inflationary problems in times of rising costs. The consequential implications for the management of inflation will be considered in the concluding chapter.

Chapter 5

THE METHODOLOGY OF THE EMPIRICAL ANALYSIS

5.1 Introduction

This chapter is concerned with the methodology of the empirical analysis which will be used to test the hypotheses previously derived. Several aspects of the analysis, including data specification, will be considered in order to allow for proper appraisal of the results.

As a point of departure, some previous empirical investigations of price flexibility and adjustment will be evaluated. These studies can be subdivided into two distinct types. The first deal exclusively with the administered prices hypothesis, and they are solely concerned with the relation between price flexibility, broadly defined, and industrial structure. The second type of empirical studies concentrate on the econometrics of price determination and adjustment *per se*, and in addition they examine issues such as the "normal cost hypothesis" and the influence of demand on prices. The latter do not consider the administered prices hypothesis, and in many the estimates of the price equations have been at a high level of aggregation which did not allow inter-industry comparison. One notable exception is the early study by Yordon (1961) in which the effect of demand across a sample of fourteen industries in the U.S. was examined.

This review is not intended to be exhaustive and will not encompass all the empirical studies which are of relevance. Rather, its purpose is to bring out the salient features of previous investigations with a view to avoiding the repetition of previous shortcomings and draw on useful lines of inquiry wherever possible.

5.2 Tests of the Administered Prices Hypothesis

When Means first submitted his hypothesis in 1935 he also produced statistical evidence to support it. This consisted of some 677 monthly prices tabulated in terms of the frequency of price change. For the period from 1926 to 1933 Means found that 14 prices did not change at all and 77 prices changed only between one to four times. On the basis of this evidence Means then proceeded to divide the prices in his sample into a set of "administered" prices which displayed little variability over time, and another set which he called "market dominated" and which displayed considerable flexibility. Further evidence and arguments in support of the thesis were submitted in 1957 to the Kefauver Committee, and a case was made suggesting that the world-wide inflation of the 1950's was due to price administration.

Means' methodology has not changed much since his original 1935 contribution. Essentially, it consists of noting the frequency and direction of price movements over selected time periods - usually upswings and downswings of the trade cycle. This kind of statistical analysis, although useful because it sheds some light on relative price movements, is unsatisfactory in one important respect. Simply looking at the frequency of price changes through the cycle does not reveal very much about how those prices would have behaved had they been "market dominated". Furthermore, since industries experience different levels of cost and demand fluctuations during the cycle, their price movements will naturally reflect these movements. However, Means' statistical tests make no allowance for this and consequently inter-industry differences in price flexibility allegedly due to administration could be the result of dissimilarities in cost and demand influences.

Thus, before comparisons of price flexibility can be made across industries, it is necessary to normalise for the cost and demand conditions which lie behind price movements.

Depodwin and Selden (1963) undertook some critical tests of the hypothesis. Their methodology involved single variable regression analysis of price movements during the 1953-1959 period. The dependent variable consisted of an index of price change over the period, and the explanatory variable was, alternately, the four- and eight-firm concentration ratio. The authors found no evidence in support of the hypothesis and concluded that price administration did not contribute significantly to inflationary pressures during the period.

The weakness of this analysis, like that of Means, lies in its neglect of other important factors which influence price movements. The omission of cost and demand variables from the regression tests would seriously bias any inferences about the impact of market concentration.

A more sophisticated, multiple regression methodology has been adopted recently by other researchers. Weiss (1966) tested the hypothesis using price as the dependent variable and costs, output[1] and concentration as explanatory variables. Weiss found that concentration had a positive and statistically significant effect on prices in only one period (1953-1959). But Phlips (1971), using European data, found no evidence in support of the hypothesis.

Stigler and Kindahl (1970) opened a new chapter in this debate by compiling indices based on transactions prices. Conventional price index numbers reflect sellers' quotations, and it has often been argued that these are mere benchmarks around which transaction prices fluctuate. Stigler and Kindahl thus maintained that price administration could be a statistical phenomenon which stems from the method of collecting price data.

---

(1) An index of output was used as a proxy for demand.

The new NBER[1] indices were therefore compared with the conventional BLS[2] indices. A breakdown of price movements in two recessions[3] is given in Table 5.1 below:

Table 5.1 Price Movements in Two Recessions

Price Change	All Prices		Excluding Steel Products	
	BLS	NBER	BLS	NBER
Decreases	23	40	23	40
No change	19	10	16	7
Increases	26	18	18	10

Source: Stigler and Kindahl (1970)

On the basis of these results Stigler and Kindahl drew the following conclusion:

> ".... we find no evidence here to suggest that price rigidity or "administration" is a significant phenomenon".

Means (1972) disagreed with this conclusion and held that, on closer scrutiny, the NBER data supported his own hypothesis. To demonstrate this he divided the price data into "administered" and "market dominated" sub-samples. The results for the two recession periods are shown in Table 5.2 below:

Table 5.2 Price Movements in Two Recessions

Price Change	Total NBER Sample	"Administered"
Decrease in both recessions	22	7
Not decreasing in both	46	46
Total	68	53
% Decreasing in both	32%	13%

Source: Means (1972)

Means interpreted table 5.2 as providing corroborative evidence but the link between administration and inflation remains obscure. Furthermore, the definition of "administration dominated" prices was not clarified.

(1) National Bureau of Economic Research
(2) Bureau of Labour Statistics
(3) July 1957 - April 1958, May 1960 - February 1961

Lustgarten (1975) carried out a comprehensive set of tests using regression analysis and, in addition, reviewed much of the empirical literature on the subject. His basic equations differed little from the conventional specification and they included labour costs, material and capital costs, and measures of concentration as explanatory variables. The modern version of the administered prices hypothesis suggests that administered prices will lag behind market dominated prices during upswings, and move in a countercyclical direction during the downswing. Thus Lustgarten's a priori expectation was for concentration to have a negative sign in the lag period (upswing) and a positive sign in the catch-up period (downswing). Using 225 4-digit industries in the U.S., the regressions were estimated for twelve separate annual time periods between 1958 and 1970. Lustgarten found that generally the results were not favourable to the administration hypothesis. He then went on to look at the influence of demand on prices, since according to the hypothesis, changes in demand have a lesser impact on price movements in concentrated as opposed to unconcentrated industries.

Lustgarten's significant innovation lay in his abandoning the traditional proxy variables for demand in favour of a variable which was constructed using an input-output methodology. The construction of this variable will be elucidated in section 5.5.

On testing the hypothesis relating to the influence of demand using dummy variables for different concentration levels, Lustgarten found that demand had a uniform effect on prices across the entire concentration spectrum. Furthermore, the overall impact of demand, based on an all-industry sample, was found to be small in magnitude but statistically significant from zero.

Summing-up these results, Lustgarten concluded that the evidence did not support the administered inflation thesis. This conclusion is significant because his tests were the most comprehensive to date and represented an improved statistical specification.

5.3 The Econometrics of Price Determination

A considerable body of analysis exists on the subject of price formation. This literature is not concerned with the problem of administered prices per se, but with theories of price determination and hence with factors leading to price changes. Although a large number of such studies exist, both for the U.S. and the U.K., most involve estimating price equations at a high (macro) level of aggregation.

The central issue which these empirical studies explore is whether prices are purely cost determined(1) in accordance with the celebrated "normal cost" hypothesis put forward by Hall and Hitch (1939), or whether they conform to the neo-classical excess demand hypothesis which states that prices are jointly determined by the forces of supply and demand.

The basic approach common to all these studies is the estimation of a price equation in which the dependent variable is price and the independent variables are respectively material costs, unit labour costs (computed in a number of ways) and in some cases also a proxy for demand such as an index of output or capacity utilisation. Capital costs are not generally included in these studies, the rationale for their omission being that short-run pricing decisions will be unaffected by changes in fixed costs since profit-maximisation dictates that price be determined by marginal costs.

A survey of price determination studies for the U.S.(2) has been conducted by Nordhaus (1972). After examining closely the functional specifications and the results obtained by the different studies, Nordhaus concludes that

> "... very little is known about the structure of the impact of demand on prices."

---

(1) Strictly speaking, "cost plus", since a mark-up over standard costs is included.

(2) Up to the year 1970.

Nordhaus is particularly critical of some methodological conventions which are common to all the studies surveyed, notably the potential simultaneous equations bias which may result from including a demand variable on the right-hand side of the equation.

Eckstein and Wyss (1972) have estimated price equations for 16 individual industries in the U.S. at 2-digit (SIC) level of aggregation. This study constitutes a welcome departure from previous aggregative price studies using U.S. data. The authors' broad conclusion was that market structure has some influence on pricing behaviour although the exact relationship is somewhat obscure. In general the lags of adjustment were found to be short with prices responding rapidly to changes in costs. Changes in demand measured by a capacity utilisation index were found to have a small but significant effect on output prices.

A recent empirical study by McCallum (1974) focused on a price equation which is deduced from an explicitly formulated demand and supply equation. Combining these relationship McCallum obtained a behavioural equation with price as the dependent variable and with wage rates, material prices, national income, price of substitute goods and a lagged dependent variable as the explanatory variables. A second model allowed for the effect of inventories on output price. McCallum invoked the theory underlying inventory holding i.e. that the optimal level of inventories is given by the condition:

$$P^e_{t+1} - P_t = \psi(I)_t$$

where P^e_{t+1} is expected price in period t+1 and $\psi(I)$ is the marginal cost of storing inventories. Using an adaptive expectations model to estimate P^e_{t+1} and substituting that expression in the demand relation the author obtained a price equation which included inventory holding $(I)_t$ as an additional explanatory variable. McCallum chose the lumber industry for the empirical testing on account of its atomistic structure. The results of the supply and demand specification were generally robust. The explanatory power of the regressions was high, all the coefficients had the expected signs, and they were also highly significent. The inventory specification was equally successful with the coefficient on the inventory variable taking the expected i.e. negative sign as well as being statistically significant. The author's conclusion was that the inventory model was generally superior to the less complex supply and demand formulation.

One weakness of McCallum's study is the omission of any discussion relating to the institutional setting within which lumber prices are set. If there is no central "clearing system" then, although the industry is atomistic, firms will be price setters. In this case it is not strictly correct to specify an industry supply schedule since each firm sets its price in light of cost, demand, and competitive[1] conditions. However, the functional specification of the model is consistent with an imperfectly competitive price adjustment model since the explanatory variables included in the latter are the same as those of the supply-demand specification. Therefore McCallum's results do not provide definitive evidence on the structure of competitive price adjustments.

Yordon (1961) in an early U.S. study of pricing behaviour attempted to identify the impact of industry structure on price adjustment. Yordon used monthly data for a sample of 14 industries which were split into two categories: concentrated and unconcentrated.[2] The industry price equations included three independent variables, labour costs, material costs, and capacity utilisation as a demand proxy. Yordon found little difference in the magnitude of price adjustments to cost changes between the two industry groups. However the finding may be due to the fact that Yordon's sample of industries was not clustered around high and low concentration levels thus

(1) This relates to the prices charged by rivals, which each firm needs to consider for its own pricing decision.

(2) Following Kaysen and Turner a concentrated industry is defined in terms of a four-firm concentration ratio of 49% or above.

rendering sample means tests somewhat hazardous. Yordon also found that concentrated industries appeared particularly insensitive to demand effects.

Neild (1963) conducted an early empirical study for the U.K.. One of the objectives of the study was to test the Godley hypothesis, which stated that firms' pricing behaviour is based on long-term estimates of productivity. This is in contrast with the view that prices respond to short-run changes in output per man. Neild therefore deflated the wage rate variable by a long-run productivity estimate (2.5% p.a.). The price equation also included material prices and a lagged dependent variable. Neild's results for the period 1950-60 appeared to support the normal cost hypothesis. A demand proxy was introduced in the equation, namely a measure of the excess of vacancies over unemployment.(1) The estimated demand coefficients turned out negative and insignificant and were consequently not reported. Neild extended his price equation analysis to five broad industry groups (SIC-order level), but no attempt was made to link industry structure to observed pricing behaviour. Neild also found the lag of price behind cost to be fairly short - between 3 to 6 months.

A recent test of the normal-cost hypothesis is that of Godley and Nordhaus (1972). The methodology involves identifying all the components of unit costs including taxes and services. These costs are then purged of reversible cyclical components. The authors assumed historical cost pricing i.e. the cost of each input was calculated at the time of purchase. With this assumption the distributed lag between cost and price could be determined without recourse to the data. The predicted price in period t was then estimated as follows:

$$P_t = (\text{1963 mark-up}) \times (\text{Historical normal unit cost})_t$$

The authors then compared the actual with the predicted aggregate price index. The two series followed each other closely but the authors were unable to explain the fall of the mark-up over cost since 1964 as shown by a continuously

(1) This index is compiled by the National Institute of Economic and Social Research.

widening gap between the actual and predicted series.

To test the normal cost hypothesis Godley and Nordhaus regressed the change in the logarithm of actual price on the change in the logarithm of predicted price and a measure of capacity utilisation. The results were as follows:

$$(1) \quad \Delta \log P_t = \underset{(1.42)}{0.001399} + \underset{(5.36)}{0.6248} \Delta \log \hat{P}_t + \underset{(0.66)}{0.000238} \log (X/XN)_t$$

$\hat{P}$ is the predicted price and figures in brackets are t-statistics. The authors tested a large number of other proxies for demand, most of which turned out to be statistically insignificant, and they concluded that the evidence strongly supported the normal cost hypothesis.

5.4 The Empirical Analysis: Outline of the Methodology

The analysis of price adjustment in chapter 4 was conducted at the level of the "representative" firm. The testing of the hypotheses which are based on that analysis will involve estimating a set of price adjustment equations. However, although the empirical testing should also be conducted at the firm level, time-series data on costs and prices is not available at this level of aggregation. As an alternative the regression equations will have to be estimated at the industry level. It is clear that the estimated coefficients will represent an average for all firms within an industry. The question which arises, therefore, is whether these coefficients can be interpreted in the same way as if they were estimated for each firm individually. We would contend that this is so because the crucial determinant of search and adjustment costs in our model is industrial structure, as measured by an index of concentration. Thus, since it is the influence of this parameter on the adjustment process which is being tested, and since the degree of concentration is the same for <u>all</u> firms within an industry, its impact at the firm and the aggregate industry level will be much the same. As a result, we can be confident that the industry-level estimates will constitute a valid test of our hypotheses.

The empirical analysis will be divided into three parts. The first will be concerned with the influence of short-run changes in demand on price adjustments. Notwithstanding the existing empirical studies in this area, some of which were reviewed above, our own analysis will be based on an improved specification of the demand variable and a relatively low (MLH) level of aggregation.

In the second part we shall test the hypothesised relationship between market structure and the rate of price adjustment. This will essentially involve estimating the rate of adjustment for different industries using time-series regressions, and then linking these estimates cross-sectionally to industrial structure.

Finally, the third part will consist of an analysis of structural breaks in the price adjustment process. Using covariance tests, we shall examine the impact of acquisitions and mergers on the rate of price adjustment in the wake of the mergers boom which took place in the late 1960's and early 1970's.

5.5 The Influence of Demand

The effect of demand on prices has been the subject of several empirical tests, all of which employed some proxy index of demand in the price equations. The variables most commonly used for this purpose were indicators of excess demand for labour (e.g. Neild, 1963), capacity utilisation, or some measure of output. These demand proxies were introduced into the equation either in terms of period-to-period changes or in terms of levels. But as Lustgarten (1975) and Nordhaus (1972) have indicated, these measures of demand are prone to estimation bias and should generally be treated with caution.

The excess demand for labour variable is in general negatively correlated with short-run labour costs, since, when excess demand is high, the rate of production will also be high thus depressing labour costs. Therefore, if long-run labour costs are included in the price equation along with the excess demand for labour variable, then the latter will pick up the effect of changes in short-run labour costs and thus exert a negative bias on the estimated coefficient. However, this bias will be present only if prices are adjusted to short-run changes in labour costs.

As regards the capacity utilisation variable, which has been used extensively (e.g. Eckstein and Fromm, 1968) and has proved to be consistently positive and significant, its overall influence in terms of the size of the coefficients has generally been small.

As regards output indicators, which have also been used extensively in empirical studies as demand proxies, these present a number of problems. First, output is not really a measure of demand but represents the joint outcome of the supply and demand decision. This constitutes a source of estimation bias.

Second, as pointed out by Lustgarten (1975), output indicators are usually compiled by deflating the values of deliveries with an output price index. For this reason, changes in the output indicators will generally be inversely correlated with output price thus causing a downward bias in the estimated coefficient.

The final problem associated with output indicators is the simultaneity bias which may arise in ordinary least squares regressions. To illustrate this problem, consider the following price adjustment model for an industry i :

(2) $$dp_{it} = a + b_1 dq_{it} + \varepsilon \qquad b_1 > 0$$

(3) $$dq_{it} = c + b_2 dp_{it} \qquad b_2 < 0$$

Equation (2) is the industry price adjustment equation where the cost variable has been dropped in order to simplify the analysis. Equation (3) is a simplified demand function in first difference form. We shall assume that both equations represent the true model.

Now, if equation (2) is estimated by ordinary least squares regression it can be shown that the $\hat{b}_1$ estimator will be biased. The bias arises because the explanatory variable and the error term are no longer independent in equation (2), given the specification of the model.

To see this consider the $\hat{b}_1$ estimator in deviation form which is defined as:

$$\hat{b}_1 = \frac{\Sigma dq_{it} dp_{it}}{\Sigma dq_{it}^2}$$

Substituting equation (2) above for dp_{it} and taking expected values this estimator reduces to:

$$(4) \qquad E(\hat{b}_1) = b_1 + E\left(\frac{\Sigma dq_{it}\varepsilon}{\Sigma dq_{it}^2}\right)$$

The second term on the right hand side of (4) is the covariance between dq_{it} and the error term ε. Using the reduced form of equation (3) this covariance can be shown to be:

$$Cov(dq_{it}\varepsilon) = \frac{b_2}{1-b_2 b_1} \sigma_\varepsilon^2$$

Now, since $b_2 < 0$ it therefore follows that $E(\hat{b}_1) < b_1$. Hence there is an <u>a priori</u> expectation of a downward bias in the demand coefficient. This bias may account for the generally poor results obtained in the past with output indicators.

To avoid these problems we used the method suggested by Lustgarten (1975). Instead of using observations on output of the industry whose price adjustments are being explained, the method involves using output data of industries which use the product of the industry in question in their own production process. This index of demand is defined as the weighted sum of the gross output indicators of user industries, where the weights are the respective input-output coefficients. A detailed description of the data sources and methods which were used in the construction of this index will follow in section 5.9.

The advantage of this index rests on the fact that it avoids three major problems commonly encountered with the measurement of demand. First, since it is not related to the output of the industry whose price is the dependent variable, there will be no inverse correlation caused by the usual method of deflating the index of deliveries by output price. Second, given that this index does not measure the actual output in the industry to which it relates, it should not reflect, as demand indicators often do, the joint supply and demand decision. Finally, and what is perhaps most important, the estimation problems resulting from the simultaneous price and demand relationships of the type which was illustrated above, are neatly circumvented by the use of this index. Hence ordinary least squares regressions may be used without danger of estimation bias.

Nevertheless, the proposed demand index does suffer from two drawbacks. It is clear from its definition that the index is derived from observations on intermediate output only, and consequently the direct influence of final demand is implicitly ignored. However, given that we would expect a strong correlation between changes in intermediate and final output, this should not constitute a major weakness. The other difficulty stems from the fact that the U.K. Index of Industrial production is only available at an SIC-order level of aggregation. As our empirical tests will involve industries which are classified at a lower, MLH level of aggregation, the suggested index will represent an approximation to the one which should ideally be used. Notwithstanding these qualifications, the proposed index was considered to be preferable to conventional demand indicators, and was employed in the empirical analysis.

5.6 The Influence of Market Structure

Of the two hypotheses which were derived in the previous chapter, one was concerned with the influence of market structure on the rate of price adjustment. In order to test this hypothesis, as well as the one concerning the influence of demand, a set of industry price adjustment equations will be estimated using regression analysis. In addition to providing a measure of the impact of cost and demand changes, the regression equations will also give estimates of the rate of price adjustment in each industry.

The equation used for estimation was derived from the partial adjustment model in the following manner. Equation (17) of the preceding chapter was given as:

$$(5) \qquad \Delta P_t = \lambda(P_t^* - P_{t-1})$$

where λ is the adjustment coefficient and P_t^* represents the current period equilibrium price. This equation may be rewritten as:

$$(6) \qquad P_t = \lambda P_t^* + (1-\lambda)P_{t-1}$$

Replacing the equilibrium price P_t^* by a linear combination of the marginal cost and demand variables, the above equation becomes:

$$(7) \qquad P_t = \lambda\beta_1 C_t + \lambda\beta_2 D_t + (1-\lambda)P_{t-1}$$

where C_t and D_t represent current period marginal costs and demand respectively. This is the familiar price equation with a lagged dependent variable on the right hand side; its estimation would require data on output prices, input prices and demand. However, since these variables are strongly trended, multicollinearity in the regressions is likely to result in highly imprecise estimates of the coefficients. To overcome this problem we took the first difference of equation (7), and consequently the functional specification used for estimation was linear in first-differences, as defined by equation (8) below:

$$(8) \qquad \Delta P_t = \lambda\beta_1\Delta C_t + \lambda\beta_2\Delta D_t + (1-\lambda)\Delta P_{t-1}$$

It should be noted that this specification implies the same lag of price adjustment to changes in cost and demand, since only one partial adjustment coefficient is estimated. This methodology was adopted for two reasons. First, there was no suggestion in the dynamic analysis of the previous chapter that a differential lag structure is the appropriate one. Second, when the estimating equation is suitably modified to incorporate one adjustment coefficient for cost changes and one for demand changes, it is found that lagged values of the explanatory variables appear on the right hand side of the equation. This would lead to severe multicollinearity in the regressions, with all the associated estimation problems.

The price adjustment equations will provide an estimate of the partial adjustment coefficient for each industry. As a first step in the analysis of the relationship between the rate of adjustment and market structure we shall employ the rank correlation method. The industries in the sample will be given a concentration ranking based on available measures of concentration, and an adjustment ranking based on the size of the estimated partial adjustment coefficients. The degree of correlation between these variables will then be evaluated by computing the Spearman's rank correlation coefficient.(1)

(1) The computational formula of this statistic will be given in the next chapter.

As a second step in the analysis we shall attempt to derive a more precise, quantitative relationship between market structure and the rate of price adjustment. For this purpose we shall link the estimated adjustment coefficients cross-sectionally to concentration and other industry characteristic variables using multivariate regression analysis. Several alternative functional specifications will be tested, and a number of different concentration measures will be used in this analysis. Details of the sources and methods used in constructing the indicators of concentration will be given in section 5.8 below.

5.7 The Analysis of Structural Breaks

In the final section of the empirical analysis we shall examine whether any structural changes in the price adjustment equations took place during the estimation period. The purpose of this is, essentially, to investigate whether any identified structural breaks could be linked to the rapid changes in concentration which resulted from the wave of horizontal mergers and takeovers which occurred in the late 1960's and early 1970's. Of relevance in this context is Stoneman's (1976) conclusion that approximately 50% of the changes in concentration which were observed during the 1960's could be attributable to mergers and takeovers.[1] If this conclusion is accepted, and if changes in concentration exert an influence on the price adjustment process, then there could be important policy implications concerning the long-run effects of mergers on the rate of inflation in the U.K. The discussion of these implications will be deferred to a later chapter.

The analysis will again involve estimating a number of price adjustment equations for a sub-sample of industries. However, in order to identify any structural breaks, these equations must allow for changes in

(1) This was based on an extensive survey of the current evidence.

the partial adjustment coefficients in the post-merger period. One way of doing this would be to introduce a dummy variable into the equations. We would do so by way of a 'slope dummy' on the lagged dependent variable, the latter being our estimate of the adjustment coefficient. However, there are problems with this procedure. Since the estimated coefficients in the price equations incorporate the partial adjustment coefficient, a slope dummy solely on the lagged dependent variable (ΔP_{t-1}) would force a change in the cost coefficients for the post-merger period, unless the dummy coefficient was insignificantly different from zero. To see this consider equation (8) from which the demand variable is excluded:

$$\Delta P_t = \lambda\beta_1 \, \Delta C_t + (1-\lambda)\Delta P_{t-1}$$

Now call the coefficient on ΔC_t : $\xi = \lambda\beta_1$. Using the dummy variable technique we would get two estimates of the partial adjustment coefficient as follows:-

Period before mergers: λ

Period after mergers: $\lambda + \lambda_d$

Where λ_d is the coefficient on the dummy variable which captures the effect on the adjustment process of the post-merger period. However, since our estimate of ξ remains the same for the entire period we have that:

Before mergers: $\beta_1 = \xi/\lambda$

After mergers: $\beta_1 = \xi/(\lambda + \lambda_d)$

Thus it is clear that we would be imposing a change on our estimate of β_1, unless $\lambda_d = 0$ or unless ξ is allowed to change in the post merger period. It is therefore preferable to derive separate estimates of the price equations for the two periods without using dummy variables. In this way no a priori restrictions are imposed on the variables. The analysis of structural breaks in the price adjustment mechanism will therefore be based on a number of "Chow" tests. This methodology consists of splitting up the estimation period in two parts, and then computing an F statistic from the residual sum of squares of the split-period regressions. A precise definition of this F test will be given in the next chapter.

In the context of structural breaks we must also consider the anti-inflation legislation which was introduced during our estimation period. We refer in particular to the Conservative government's Counter-Inflation Programme which was implemented in November 1972. One important aspect of this programme was the creation of the Price Commission for the purpose of monitoring and regulating price increases. The Commission's task was to examine applications for price increases using the twin criteria of "allowable cost increases" and "reference profit margins". In the next chapter we shall therefore consider the potential influence of the Price Commission on the price adjustment process.

5.8 Identifying Market Structure

Market structure is a concept which is notoriously difficult to measure. In this thesis we followed convention by using the five-firm concentration ratios as indicators of industrial structure. Three sets of concentration ratios were used in the regressions, the 1963 and 1968 figures published in the 1968 Census of Production, and the more recent figures for 1971 published in the annual Census Report. Both sets of concentration ratios had their shortcomings, but since no alternative measures are available for recent years, they had to be used.

The problem with the 1963 and 1968 ratios is that most of them relate to industries which are defined at a finer level of disaggregation than those which were used for estimation. Thus, while these five-firm concentration ratios refer to specific commodity groups within an MLH classification, our price equations for the most part apply to MLH industry groups. To overcome this difficulty we based the industry structure indicators on the weighted and unweighted means of the component concentration ratios within each MLH industry class. The weights used were the values of sales for each product group. These figures are given alongside the concentration ratios in the 1968 Census. Clearly these measures will not represent the exact concentration ratio at this level of aggregation, but since individual commodities within this classification are very closely related, the firms which produce one commodity group are likely to be producers of some or all of the remainder. Furthermore for the 1968 figures the range between the lowest and the highest concentration ratio within a single MLH group exceeded 25% in only 5 out of 21 cases. Therefore we suggest that these weighted and unweighted means proposed here are likely to be good indicators of the relative concentration position of the industries in our sample, and this is vindicated by the recent studies which have used such measures of concentration in the analysis of changes in industrial structure (see George, 1975).

Turning to the 1971 concentration figures, the problem with these is that although they are defined at the required MLH level, they refer to the percentage of gross industry sales accounted for by the five largest enterprises by employment. Hence when the five largest employers are not those with the largest output the concentration ratio will be biased.

In addition, we used the Herfindahl measures of concentration constructed by M. Waterson of the University of Newcastle. These indicators are based on employment data published in the 1968 Report on the Census of Production. They relate to the years 1963 and 1968 and are based on an MLH level of aggregation.(1)

(1) These Herfindahl indices, together with the concentration ratios will be found in the appendix.

5.9 Data

A large part of the data necessary for the analysis was previously unavailable and was generated from more basic sources.

The dependent variable in the regression equations was the wholesale price index (WPI) of the relevant industry. The Department of Industry maintains a large number of continuous price series, including import prices. These WPI's are calculated at commodity and MLH levels of aggregation. The indicators are compiled free of value added tax (or purchase tax before its abolition), and represent price quotations by a number of sellers or manufacturers.(1)

On the explanatory variables side, two cost variables were included: material and fuel costs and unit labour costs.

The price index of materials and fuel (PIMF) was previously available only at a rather high, SIC-order level of aggregation. These indices had been published in Trade and Industry (formerly the Board of Trade Journal) for broad sectors of industry e.g. steel industries, chemical and allied, and the like. It was felt that the use of order level data on material costs, which must necessarily differ between MLH's could seriously bias the results, particularly as regards accurate estimates of the industry partial adjustment coefficients.

It was therefore necessary to construct a set of material cost indices (PIMF's) which related to industries defined at MLH level of aggregation. For this task the help of the Department of Industry was enlisted.

The indicators were constructed as follows. The first requirement was a breakdown of commodities purchased by each industry for purposes of production. This information was obtained from the 1968 Census of Production tables. Consider the commodities purchased by industry j for production purposes in 1968. We define S_{ij} as the amount of commodity i purchased by industry j. In effect, the Census tables give an array of

---

(1) The indices are base-weighted according to the Laspeyres formula.

such purchases, as laid out below:

		Value (£'000)
Purchases of commodity	1	S_{1j}
" " "	2	S_{2j}
....		...
" " "	n	S_{nj}
Total value of input purchases		T_j

Dividing the value of each commodity purchase (S_{ij}) by the total, we obtain a form of input-output coefficient i.e. $\hat{a}_{ij} = S_{ij}/T_j$

These input-output coefficients were used as weights in deriving the PIMF's. In compiling these weights we adhered to the Department of Industry's practice of deriving the weights on a net sector basis. This means that intra-industry transactions i.e. S_{jj} are netted out. In most industries these flows were of relatively small magnitude.

The price index of materials and fuel was then calculated as the weighted average, in period t, of the price indices of individual commodities purchased where the weights were the $\hat{a}_{ij}$'s. Thus we have:

$$PIMF_{jt} = \frac{1}{\sum_i \hat{a}_{ij}} \left[WPI_{1t}\ \hat{a}_{ij} + WPI_{2t}\ \hat{a}_{2j} + WPI_{3t}\ \hat{a}_{3j} + \ldots WPI_{nt}\ \hat{a}_{nj} \right]$$

Where $PIMF_{jt}$ is the price index of materials and fuel for industry j in period t and WPI_{nt} is the wholesale price index of commodity n in period t. Extending this calculation for all t we derived a continuous series for each PIMF covering the entire estimation period (1963-1974).

Since each industry purchases up to sixty individual commodity inputs, the calculations involved in constructing the PIMF series were too extensive to be carried out manually. These calculations were therefore performed by computer once an appropriate program had been devised.(1)

The Census Tables do not cover all purchases made by industries. Some purchases cannot be identified and they are lumped together under a "miscellaneous" heading. In some industries this category comprised 25% of total purchases. Where possible the Department of Industry investigated the broad composition of purchases within this category in consultation with the Business Statistics Office, in order to reduce the size of this category in the weighting pattern. What remained of the miscellaneous component was used to derive its weight and was included in the PIMF with a composite price index of materials constructed by the Department of Industry. This index reflects the overall trend in the price of industrial raw materials and is used by the Department of Industry in the construction of the broad sector PIMF's.

Since the weights used for calculation purposes were obtained from the 1968 Census of Production, we were implicitly assuming constant input proportions throughout the period (1963-1974). Although this assumption is somewhat contentious, there is no alternative source of input purchase information except for the 1963 Census of Production. However, some experiments with input-output coefficients in the Netherlands (see Tilanus, 1966) suggested that the majority of sizeable coefficients changed little over the 1948-1960 period.

Nevertheless, the cost indices which were obtained represent a considerable improvement on previously available data and a number of the PIMF series are to appear regularly in Trade and Industry.

The unit labour cost (ULC) index was also constructed from primary data. Quarterly observations on average earnings, which were the series used as a

---

(1) This program was written by Mark Partridge whose help is gratefully acknowledged.

measure of industries' labour costs, could only be obtained at SIC-order level of aggregation i.e. for broad sectors of industry. Whilst this deficiency could lead to errors of measurement, it is not implausible that earnings in broadly defined industrial sectors are promptly brought into uniformity through Union pressure for earnings parity. Indeed, earning differentials are not likely to be significant between MLH's within an SIC-order class, and will certainly not display the variance which might be expected with material costs.

As our basic labour cost series we therefore used the monthly index of average earnings by industry groups which is published by the Department of Employment. The series goes back to 1963 and comprises gross remuneration including overtime payment, bonuses, and commission. The index takes into account the remuneration of manual and non-manual staff.

To obtain the ULC index an allowance must be made for changes in labour productivity since actual labour costs rise only if wage cost rises exceed those of productivity. We therefore followed the majority of previous empirical studies in deflating the average earnings series by a productivity index, to obtain unit labour costs. As regards the productivity index we were faced with a choice of assumptions about pricing behaviour. The problem was whether to deflate the earnings series by a quarter to quarter productivity index (output per man) or whether to use a long-run productivity trend. In order to resolve this dilemma we plotted ULC, defined as average earnings deflated by current quarter productivity, against time. This graph showed that the ULC variable thus defined displayed considerable quarter to quarter variability from the trend which was not reflected by output price movements. We therefore opted in favour of the hypothesis, originally submitted by Godley[1], that prices do not respond to short-run changes in

---

(1) See Neild (1963), pp. 3-5.

productivity but rather to its trend. Thus the average earnings series were deflated by the long-term productivity trend in each industry, broadly defined. This trend was estimated by fitting the following equation to output-per-man data for the 1963-1974 period

$$\log (Q/N)_{it} = A + \hat{b}_i t \tag{9}$$

where $(Q/N)_{it}$ is output per man in industry i at period t and t is time. Thus $\hat{b}$ is the estimated quarterly productivity trend for industry i. The unit labour cost index was then obtained as follows:

$$ULC_{it} = \frac{IAE_{it}}{(1+b_i)^t}$$

where IAE_{it} is the index of average earnings of industry i in period t.

Thus the implicit assumption in the construction of these cost indicators was that technical progress over time reduces labour cost by exerting downward pressure on labour requirements per unit of output. Furthermore, since we assumed a fixed-coefficients technology, material inputs per unit of output were unaffected by technical progress.

The proxy variable for industry demand was compiled in the following manner. As was previously stated this index is the weighted sum of output indicators pertaining to user industries. Thus the demand index for industry i is a weighted sum of the output of all industries which use i in their production process. The major difficulty lay in obtaining the weights. The ones used were aggregate input-output coefficients derived from the 35 x 35 commodity by industry absorption matrix published in "Structural Change in the British Economy 1948-1968" (1974).(1) An element of the

---

(1) A Programme for Growth, Volume 12.

absorption matrix x_{ij} shows the amount of commodity i absorbed by industry j in its production process. This matrix is based on 1963 trade flows between industries. In order to harmonise the 35 x 35 industry classification with that of the Index of Industrial Production - the output indicator which was used - the absorption matrix was aggregated into an 18 x 18 commodity-industry matrix[1].

Thus the demand index for industry i's output in period t is given as:-

$$D_{it} = \frac{1}{\sum_j x_{ij}} \left[x_{i1} Q_{1t} + x_{i2} Q_{2t} + \ldots x_{in} Q_{nt} \right]$$

Two simplifying assumptions were involved in the construction of this demand index. First, since our observations relate to demand at SIC-order level whilst our equations explain price changes defined at MLH level, we are implicitly assuming that changes in demand are evenly spread through broad sectors of industry. Second, since the x_{ij}'s are derived from a commodity by industry flow matrix, in order for the x_{ij}'s to be equivalent to the input-output coefficients a_{ij}'s we must assume that each industry produces only its principal product. An examination of the "makes" matrix which shows the amounts of different commodities, including principal products, which are produced by each industry, revealed that although this assumption was not strictly valid in all cases, the off-diagonal elements of the "makes" matrix comprised a small proportion of total industry outputs[2]. Hence for purposes of constructing a demand proxy this assumption need not be viewed with concern.

It should be noted that our index was made up of intermediate demands only i.e. inter-industry transactions, and that final demands were excluded.

---

(1) This matrix will be found in the appendix.

(2) The "makes" matrix, for 1963, is also given in the appendix.

As Lustgarten (1975) pointed out, this omission was unavoidable since the proportion of gross output which goes to final demand displays a marked variability over time. Nevertheless in most of the 18 broad sectors of industry used in this analysis intermediate purchases accounted for well over half of gross output.

5.10 Concluding Remarks

In this chapter we reviewed a number of empirical studies on the subject of pricing behaviour and developed our own methodology taking due care to avoid those problems which have arisen in the past. The research methodology was discussed in detail and the assumptions made were elucidated.

An important requirement for our empirical analysis was the need to improve on existing data in light of the regression specification. The major innovation lay in the construction of a materials and fuel price index at a disaggregated (MLH) industry level. This index was constructed with the help of the Department of Industry Wholesale Prices Section. The labour-cost and demand indices essentially involved adaptations of previous research methodology.

In the next chapter the empirical results will be reported and discussed, together with the specification of the functional forms and descriptions of the relevant statistical tests.

Chapter 6

THE EMPIRICAL FINDINGS

6.1 Introduction

In this chapter we shall report the empirical results and assess their significance. In section 6.2 we shall present the empirical tests of the hypothesis which was developed in chapter 4 concerning the influence of short-run changes in demand on price adjustment. The analysis will consist of estimating regression equations through which the effect of changes in demand may be identified.

Section 6.3 will comprise the empirical tests of the relationship between industrial market structure and the rate of price adjustment. The estimates of the partial adjustment coefficient will be derived from time-series regression equations, and these estimates will then be linked to industrial structure using cross-section regression analysis and rank correlation tests.

In section 6.4 we shall attempt to estimate the specific influence of important mergers on the price adjustment process. The approach will consist of identifying structural breaks in the adjustment process by means of covariance tests. This section is not directly related to the theoretical analysis of chapter 4, but it is of interest nevertheless in view of the rapid changes in industry structure which have occurred during our period of investigation as a result of intensive merger activity. In this section we shall also consider the potential influence of changes in the overall rate of inflation on the adjustment process, using the same analytical framework.

Finally, section 6.5 will be devoted to a summing-up of the empirical analysis and will include a balanced appraisal of the results.

6.2 The Influence of Demand on Price Adjustment

In this section we shall report the results relating to the influence of demand. The analysis consisted of estimating a set of industry price equations in first-difference form. These equations included a proxy index of demand. Our sample comprised a total of twenty-one industries identified at MLH level or below and selected from seven different orders of the 1968 Standard Industrial Classification. As far as possible, we selected industries which ranged widely across the spectrum of concentration, but the sample was ultimately restricted by the availability of data. The estimation period extended from 1963-1974, giving 48 quarterly observations in total.

The functional specification of the regressions was as follows:

$$(1)\quad \Delta WPI_{it} = A + \lambda_i\beta_{1i}\Delta PIMF_{it} + \lambda_i\beta_{2i}\Delta ULC_{it} + \lambda_i\beta_{3i}\Delta PRX_{it} + (1-\lambda_i)\Delta WPI_{it-1} + u_{it}$$

where WPI_{it} is the wholesale price index of industry i in period t, and $PIMF_{it}$, ULC_{it} and PRX_{it} are respectively the price index of materials and fuel, the unit labour cost index and the demand proxy index of industry i in period t.(1)

Our proxy index of demand is a weighted sum of output indicators of user industries, as was described in the previous chapter. However, since user industries carry stocks of intermediate inputs to meet contingent increases in output, it will take some time before increases in output of user industries are felt as increases in demand of supplying industries. In order to take proper account of this time-lag in our analysis, we regressed WPI_{it} on PRX_{it-1} i.e. we lagged the demand proxy index by one quarter. In addition to carrying stocks of materials, many firms also have long or medium-term contracts with intermediate input suppliers

---

(1) These index numbers had a common base-date, namely 1963 I = 100.

and fixed-wage contracts with employees. In order to allow for their delayed impact, we also obtained a set of regression estimates based on lagged values of PIMF and ULC. In four equations the lagged variables gave an improved overall estimate.

In order to avoid excessive repetition we shall restrict our discussion, in this section, to the general explanatory power of the regression and in particular to the estimated demand coefficients. Hence the analysis of the adjustment lag and cost coefficients will be presented in the subsequent section of this chapter.

The ordinary least squares results for the engineering and non-engineering industries are reported in tables 6.1 and 6.2 respectively. This breakdown of our industry sample has no significance in the present analysis but will be elucidated further in section 6.3.

At first glance the results suggest that the explanatory power of the regressions is reasonably good, especially in view of the fact that the dependent variable is the "highly noisy" quarterly first-difference of output price. However, closer inspection reveals significant negative serial correlation in the residuals of most equations. This is indicated by the h statistic, devised by Durbin for testing the presence of serial correlation in equations which include a lagged dependent variable on the right hand side. Since h has the standard normal distribution, if it exceeded - 1.675 we rejected the hypothesis of zero negative serial-correlation at the 5% level of significance.

Serially correlated residuals are often an indication that an important explanatory variable has been omitted or that the model has been incorrectly specified. Since neither of these was applicable to our equation we would conclude that the auto-regressive scheme was the result of taking first-differences of index numbers together with

Table 6.1 Price Adjustment Equations: Engineering Industries. Dependent Variables ΔWPI_t

Demand Proxy Included. Ordinary Least Squares Estimates

MLH	Industry Description	Constant	$\Delta PIMF_t$	ΔULC_t	ΔPRX_{t-1}	ΔWPI_{t-1}	R^2	F(4,40)	h
332	Metal Working M-T	-0.1152 (-0.3273)	0.4344 (5.4610)	0.1154 (0.9382)	-0.1134 (-1.0292)	0.6635 (6.3710)	0.8925	85.0984	-2.8559
333	Pumps, Valves and Compressors	0.0504 (0.1569)	0.1600 (3.7022)	0.1929 (2.1368)	0.0290 (0.3158)	0.7334 (6.9740)	0.8539	59.9078	-2.0776
339/1	Mining Machinery	0.1338 (0.5661)	0.1263 (2.9679)	0.2224* (3.3411)	-0.0544 (-0.6956)	0.5502 (4.9555)	0.8016	41.4091	-1.4959
361	Electrical Machinery	-0.2134 (-0.6564)	0.1123 (2.8800)	0.2060 (2.0894)	0.0746 (0.7624)	0.8085 (6.8396)	0.8464	56.4866	-2.4464
362	Insulated Wires and Cables	0.1978 (0.2137)	0.3263 (8.8627)	-0.0160 (-0.0782)	-0.1382 (-0.5078)	0.6613 (8.0531)	0.7919	38.9994	†
363	Telegraph and Telephone Apparatus	0.3010 (0.4561)	0.1420 (1.2793)	0.6668* (4.2472)	-0.4158 (-1.998)	0.2181 (1.5290)	0.4832	9.5852	†
365/2	Broadcast Receiving Equipment	-0.1384 (-0.7423)	0.1403 (2.7891)	0.0218 (0.4511)	0.0586 (1.0672)	0.3752 (1.7620)	0.4641	8.8777	0.7425
368	Domestic Electrical Appliances	-0.1171 (-0.7248)	0.1480** (4.2682)	0.1080 (2.0604)	-0.0408 (-0.8322)	0.5979 (6.0859)	0.8318	50.679	-1.4512
369	Other Electrical Goods	-0.0043 (-0.0119)	0.1226 (2.7759)	0.3218 (3.3224)	-0.1166 (-1.1135)	0.4888 (3.6553)	0.7212	26.5178	-2.3241

Notes: * ΔULC_{t-1} ; ** $\Delta PIMF_{t-1}$
† h statistic not calculable
t-ratios given in parenthesis

WPI: Wholesale Price Index
PIMF: Price Index of Materials and Fuel
ULC: Unit Labour Costs
PRX: Proxy Index of Demand
h: Durbin's Statistic adjusted for lagged dependent variable

Table 6.2 Price Adjustment Equations: Non-engineering Industries. Dependent Variable ΔWPI_t

Demand Proxy Included. Ordinary Least Squares Estimates

MLH	Industry Description	Constant	$\Delta PIMF_t$	ΔULC_t	ΔPRX_{t-1}	ΔWPI_{t-1}	R^2	F(4,41)	h
272/1	Pharmaceutical Chemicals	0.3931 (0.8078)	0.1585 (1.8642	0.3216 (3.8412)	−0.2665 (−1.4429)	0.5199 (3.3340)	0.6312	17.5431	†
272/2	Pharmaceutical Preparations	0.0633 (0.4490)	0.1110 (4.5056)	0.0769 (2.6555)	−0.1016 (−1.8860)	0.7220 (7.0825)	0.8669	66.7558	−2.0776
274	Paint	0.5786 (1.0831)	0.2831 (3.5480)	0.4214* (4.6409)	−0.2660 (−1.4035)	0.3866 (2.9861)	0.6899	22.8033	†
411	Man-made Fibres	−1.0031 (−4.2650)	0.4145 (9.4295)	0.5857 (8.7893	−0.0239 (−0.3070)	−0.0173 (−0.2425)	0.8897	82.6658	−0.7529
414	Woollen and Worsted	0.6311 (1.7152)	0.3698 (8.0862)	0.0937 (0.8799)	−0.1324 (−1.0566)	0.3552 (3.9449)	0.8297	49.9373	−3.859
419	Carpets and Rugs	0.2483 (0.6825)	0.3801 (4.6801)	0.2201 (2.2671)	0.0620 (0.5956)	0.3547 (3.0370)	0.6306	17.5010	−1.0384
422/1	Household Textiles	0.3126 (0.9236)	1.0835 (10.0957)	−0.0308 (−0.3843)	−0.1429 (−1.4030	−0.1667 (−1.5081)	0.8989	91.0849	−1.9553
461	Bricks and Refractory Goods	−0.0762 (−0.2467)	0.4821 (9.9596)	−0.0017 (−0.0191)	0.1375 (1.7834)	0.4143 (4.3601)	0.8721	69.8607	−3.3263
462	Pottery	0.3416 (1.0654)	0.3751 (5.1339)	0.2585 (3.4834)	−0.0965 (−1.3214)	0.3800 (3.5668)	0.8013	41.3363	−0.3700
469/1	Abrasives	0.6942 (1.0958)	0.7119 (4.2028)	0.5126 (3.5190)	−0.2961 (−1.6791)	−0.2511 (−1.9256)	0.6863	22.4271	†
473	Bedding	0.0088 (0.0233)	0.5550 (6.4376)	0.0764 (1.0254)	0.0132 (0.2264)	0.3602 (3.2446)	0.8112	44.0269	−1.1345
483	Manufactured Stationery	−0.3056 (−0.9418)	0.3120 (4.7212)	0.2922 (3.3200)	0.0066 (0.1148)	0.6469 (6.5128)	0.9166	112.606	−1.5545

Notes: * ΔULC_{t-1}

† h statistic not calculable
t-ratios given in parentheses

WPI: Wholesale Price Index
PIMF: Price Index of Materials and Fuel
ULC: Unit Labour Costs
PRX: Proxy Index of Demand
h: Durbin's Statistic adjusted for lagged dependent variable

the inclusion of a lagged dependent variable.

In general, auto-correlation does not lead to bias in the estimated coefficients. However, when a lagged dependent variable is included in the equation and auto-correlation is present, ordinary least squares regression will yield biased estimates. The extent of bias will depend on the severity of the auto-correlation. It was therefore considered inappropriate to use ordinary least squares estimates.

Instead, we used an estimation method known as Generalised Least Squares. This method consists of a two-stage estimation technique by which the data is first transformed using an estimated value of ρ - the auto-correlation parameter - and ordinary least squares are then applied to the transformed data. In this way, the autocorrelation is first removed so that ordinary least squares may be applied without danger of bias. The technique which was used to determine the appropriate value of ρ for each equation is known as the Cochrane-Orcutt iterative process.[(1)]

The generalised least squares results are reported in tables 6.3 and 6.4. It is immediately apparent that whilst the degree of explanatory power was not reduced, the negative auto-correlation was effectively removed, as testified by the h statistics.

Looking at the estimated demand coefficients, we note that in fifteen of the twenty-one equations they were insignificantly different from zero at the 5% level. However, in five equations,namely those of the Metal Working Machine Tools, Telegraph and Telephone Apparatus, Pharmaceutical Preparations, Paint and Abrasives industries, the demand coefficient had the wrong i.e. negative sign and was statistically

---

(1) See Johnston (1972), pp. 259-265.

Table 6.3 Price Adjustment Equations: Engineering Industries. Dependent Variables ΔWPI_t

Demand Proxy Included. Generalised Least Squares Estimates

MLH	Industry Description	Constant	$\Delta PIMF_t$	ΔULC_t	ΔPRX_{t-1}	ΔWPI_{t-1}	R^2	F(4,40)	h	ρ
332	Metal Working M-T	-0.1608 (-0.6175)	0.4080 (6.4894)	0.1263 (1.0891)	-0.1735 (-1.6653)	0.7097 (7.6859)	0.9043	94.52	-0.4043	-0.3588
333	Pumps, Valves and Compressors	-0.0601 (0.2600	0.1965 (5.5747)	0.2794 (3.536)	-0.0165 (-0.1898)	0.6584 (7.4452)	0.8684	65.9736	-0.1695	-0.4088
339/1	Mining Machinery	0.0635 (0.3546	0.1209 (3.6104)	0.1612* (2.4938)	-0.0550 (-0.6979)	0.6825 (7.3495)	0.8154	44.1576	-0.1245	-0.3667
361	Electrical Machinery	-0.2262 (-0.9851)	0.1044 (3.5464)	0.2448 (2.6747)	-0.0422 (-0.4637)	0.8138 (7.8371)	0.8646	63.8777	-0.3986	-0.4088
362	Insulated Wires and Cables	-0.1344 (-0.2228)	0.3525 (1.3072	0.0922 (0.5826)	-0.2846 (-1.2543)	0.6798 (11.3297)	0.8364	51.1176	†	-0.4997
363	Telegraph and Telephone Apparatus	0.1668 (0.3162)	0.1031 (1.0774)	0.5806* (3.7957)	-0.4280 (-2.0525)	0.4269 (3.1032)	0.5002	10.0067	†	-0.3068
365/2	Broadcast Receiving Equipment	-0.1593 (-1.0730	0.1179 (2.5775)	0.0347 (0.7334)	0.0645 (1.1457)	0.4567 (2.3343)	0.4757	9.0736	0.6869	-0.2334
368	Domestic Electrical Appliances	-0.1329 (-0.9762)	0.1326 (3.9856)	0.1247 (2.4019	-0.0587 (-1.1581)	0.6248 (6.6774)	0.8370	51.33	-0.2999	-0.2332
369	Other Electrical Goods	-0.1271 (-0.5017)	0.1117 (3.3583)	0.2669 (3.0624)	-0.1387 (-1.4302)	0.6528 (5.6488)	0.7566	31.0895	-0.9791	-0.4039

Notes: * ΔULC_{t-1}
† h statistic not calculable
t-ratios given in parenthesis

WPI: Wholesale Price Index
PIMF: Price Index of Materials and Fuel
ULC: Unit Labour Cost
PRX: Proxy Index of Demand
h: Durbin's Statistic adjusted for lagged dependent variable
ρ: Estimated Serial Correlation Parameter

Table 6.4 Price Adjustment Equations: Non-Engineering Industries. Dependent Variables ΔWPI_t

Demand Proxy Included. Generalised Least Squares Estimates

MLH	Industry Description	Constant	$\Delta PIMF_t$	ΔULC_t	ΔPRX_{t-1}	ΔWPI_{t-1}	R^2	F(4,40)	h	ρ
272/1	Pharmaceutical Chemicals	0.2117 (0.4921)	0.1409 (1.8100)	0.3500 (4.1969)	−0.2163 (−1.1533)	0.5714 (3.8051)	0.6436	18.0607	†	−0.1984
272/2	Pharmaceutical Preparations	0.0383 (0.3221)	0.1066 (4.9337)	0.0782 (2.6257)	−0.0898 (−1.7047)	0.7595 (7.7230)	0.8729	68.6972	−0.5694	−0.2601
274	Paint	0.2218 (1.0190)	0.3006 (8.8494)	0.2226* (3.2522)	−0.1937 (−1.9287)	0.5897 (9.9013)	0.8673	65.3731	−0.7302	−0.8613
411	Man-made Fibres	−0.9935 (−4.6804)	0.4158 (9.9392)	0.5743 (8.4053)	−0.0136 (−0.1772)	−0.0057 (−0.0819)	0.8913	81.966	−0.0661	−0.1469
414	Woollen and Worsted	0.3956 (1.5517)	0.3817 (10.3080)	0.1961 (2.155)	−0.0881 (−0.8044)	0.3777 (5.5712)	0.8537	58.3573	−0.0747	−0.4220
419	Carpets and Rugs	0.1677 (0.6007)	0.3605 (4.9656)	0.2314 (2.436)	−0.0365 (−0.3703)	0.4442 (4.1577)	0.6452	18.1871	0.1269	−0.3238
422/1	Household Textiles	0.2726 (0.9927)	1.1019 (11.4810)	−0.0636 (−0.8399)	−0.1320 (−1.3400)	−0.1624 (−1.6167)	0.9038	93.9961	−0.0465	−0.2552
461	Bricks and Refractory Goods	−0.1168 (−0.5792)	0.4480 (11.8833)	0.0038 (0.0476)	0.1193 (1.7612)	0.4904 (6.4550)	0.8991	89.0657	−0.4251	−0.4898
462	Pottery	0.3152 (1.0386)	0.3580 (5.0194)	0.2651 (3.4158)	−0.1036 (−1.3791)	0.4009 (3.7909)	0.8001	40.0342	−0.1285	−0.0931
469/1	Abrasives	0.7192 (0.9681)	0.6683 (3.8565)	0.5763 (4.0099	−0.3728 (−2.0635)	−0.2677 (−2.0900)	0.6954	22.8284	†	0.1810
473	Bedding	0.0624 (0.2636)	0.4329 (7.3748)	−0.0375 (−0.6142)	0.0101 (0.1800)	0.6045 (7.2529)	0.8424	53.4425	−0.196	−0.5433
483	Manufactured Stationery	−0.2413 (−1.0120)	0.3315 (5.5420)	0.2578 (3.0680)	−0.0267 (−0.4754)	0.6362 (7.0167)	0.9267	126.402	−0.4157	−0.3960

Notes: * ΔULC_{t-1}
† h statistic not calculable
t-ratios given in parentheses

WPI: Wholesale Price Index
PIMF: Price Index of Materials and Fuel
ULC: Unit Labour Costs
PRX: Proxy Index of Demand
h: Durbin's Statistic adjusted for lagged dependent variable
ρ: Estimated Serial Correlation Parameter

significant. Furthermore, only in the equation of the Bricks and Refractory Goods industry was the coefficient positive and statistically significant.

The broad sweep of these results would therefore seem to be that short-run changes in demand, as measured by our indicators, do not have an appreciable influence on price adjustments. Yet the relatively frequent incidence of negative coefficients on this variable would suggest that either our index may be subject to some error of measurement or it may be picking up the effect of an omitted variable. As was indicated in the preceding chapter, there are a number of factors which have tended to exert a negative bias on conventional indicators of demand. Although our index was constructed in a way which attempted to avoid this bias, nevertheless it may have crept in unnoticed.

One major source of bias stems from measuring output as values of deliveries which are deflated by an output price index. The result of this is to cause negative bias in the coefficient on output, since increases in prices automatically deflate the value of deliveries thus creating a negative relationship between measured output and price. However, our demand indicator did not relate to the deliveries of an industry whose price changes we sought to explain, but to the weighted sum of output indicators of user industries.(1) Nevertheless, if prices of user and supplier industries move together through the cycle, then wherever price deflators are used the output indicators will themselves be correlated. In that event the negative relationship between price and the demand index will be introduced into our equations even though we used as proxy the output indicators of industries

(1) The definition of user industries was given in section 5.9 of the preceding chapter.

other than the one whose price adjustment we were attempting to explain. Therefore the negative bias which we sought to avoid may nevertheless be present in the equations.

It is difficult to determine a priori the extent of this correlation in each industry. However, close to 50% of output indicators in the U.K. are measured in terms of values of sales deflated by a price index.(1) This figure alone suggests that the potential for correlation between the indicators does exist.

The second source of bias in the demand coefficients is related to the possible misspecification of the labour cost variable. The behavioural assumption which we adopted in this analysis was that firms do not adjust prices in response to short-run changes in productivity. That is why our labour cost index was deflated by a long-run productivity trend so as to obtain labour costs per unit of output.

However, it is clear that since cyclical increases in output raise labour productivity, changes in the latter will not be reflected in our ULC index. Furthermore, cyclical increases in output will be negatively related to short-run labour costs and therefore, if firms do adjust prices to short-run changes in productivity, our index of demand may become a hidden cost variable. In that event, we would expect a negative bias on the demand coefficient because when output rises unit labour costs fall and exert a downward pressure on output price.(2) Thus, if our assumption concerning pricing behaviour is erroneous, the observed negative relationship between demand and output

---

(1) See Central Statistical Office (1970), p.2.

(2) It should be pointed out that some previous empirical studies e.g. Neild (1963) and Godley and Nordhaus (1972), have come to the conclusion that prices are unresponsive to short-run productivity changes.

price may be partly explained in terms of the misspecified labour cost variable.

It is not possible to determine a priori which of the two factors may have the largest influence on the negative bias in the demand variable. However, we would discount the possibility of a simultaneous equations bias because, as was discussed at length in chapter 5, our method of constructing the demand index ensures that the simultaneity is effectively removed.

The above discussion would indicate that although great care was taken in constructing a bias-free indicator of demand, the results suggested that this objective may not have been fully achieved. Thus, although our findings concerning the influence of demand are broadly in keeping with our hypothesis, they have to be treated with caution. A more definitive verification of the hypothesis must await the availability of more reliable data.

Yet it is interesting to note that the single equation in which the demand coefficient was positive and statistically significant was that of the Bricks and Refractory Goods industry. It is interesting because this industry is highly concentrated. Hence, whilst not being a reliable test, this evidence is consistent with our hypothesis that concentration reduces search costs associated with an adjustment of price, thereby facilitating such an adjustment to changes in demand. It also suggests that where the influence of demand is strong, the proxy index is able to pick up its effect notwithstanding its shortcomings.

6.3 Market Structure and the Rate of Price Adjustment

In this section we shall report the empirical findings concerning the hypothesis linking market structure and the rate of price adjustment. Our methodology will consist of estimating the partial adjustment coefficient for each industry in our sample and then relating them to our indicators of industrial structure.

The regression equations reported in the previous section of this chapter included a lagged dependent variable (ΔWPI_{t-1}). The coefficient on this variable represents an estimate of $(1-\lambda)$, from which the partial adjustment coefficient λ can be derived. However, as was previously shown, the proxy index of demand did not contribute to the explanatory power of the regressions and may also have incorporated some errors of measurement. Consequently, the regression equations which will be reported in this section will omit this variable. This omission implies that the estimated partial adjustment coefficient (λ) is based specifically on the rate of price adjustment to changes in costs. Nevertheless, an inspection of the adjustment coefficients obtained from the two sets of regressions showed that the omission of the demand proxy did not have a significant effect on the estimates. Thus, the functional specification of the regressions reported below was as follows:-

$$(2) \quad \Delta WPI_{it} = A + \lambda_i \beta_{1it} \Delta PIMF_{it} + \lambda_i \beta_{2i} \Delta ULC_{it} + (1-\lambda_i)\Delta WPI_{it-1} + u_{it}$$

The variables in equation (2) above are defined in the same way as in equation (1) of the preceding section. The only difference in these two equations is the omission of the demand proxy from equation (2).

In this section we shall also examine in some detail the overall fit of the equations together with the performance of the explanatory variables i.e. the price index of materials and fuel, the unit labour cost index, and the lagged dependent variable. The important innovation of our empirical analysis was the construction of an MLH-based price index of materials and fuel from basic data sources. It was felt that without this index our partial adjustment estimates would be somewhat imprecise.

The analysis of the relationship between market structure and the rate of price adjustment will be divided in two parts. As a first step, we shall test our hypothesis by means of a special form of correlation analysis. This test involves ranking the industries in our sample in descending order of concentration. Each industry will also be allocated an adjustment ranking based on the size of its estimated partial adjustment coefficient, λ. The two rankings of concentration and adjustment will be related to one another and the degree of association tested by computing the Spearman's rank correlation coefficient which is defined below:

$$R = 1 - \frac{6\sum^{n} d_i^2}{n(n^2-1)}$$

where d_i is the difference between the respective concentration and adjustment rank of industry i and n is the sample size. Since $R\sqrt{n-1}$ has approximately the standard normal distribution, the statistical significance of the rank correlation coefficient may be verified for any given level of confidence.(1) Furthermore, like the conventional correlation coefficient, R has an upper bound of +1 and a lower bound of -1. It is therefore a test statistic for negative as well as positive association between the respective ranks.

(1) See Freund (1973), pp. 433-435.

This preliminary analysis is useful in two ways. First, the correlation coefficient provides a ready indicator of any positive or negative relationship which may exist between concentration and the rate of price adjustment. In addition however, by juxtaposing the partial adjustment coefficients and the concentration ratios in the tables on which the rank correlation test is based, we were able to take a closer look at the industries in our sample and to examine those which may represent outlying observations. In this way any wide discrepancies between the expected concentration and adjustment rankings may be investigated and explained.

Since 1968 is closer to the median year of the 1963-1974 estimation period than either 1963 or 1971, the 1968 concentration ratios were used for the rank correlation analysis. Thus we attempted to ensure that the concentration ratios employed represented, as closely as possible, an estimated average for the period from which the partial adjustment coefficients were derived.

The second part of the empirical analysis will consist of a detailed multivariate regression analysis of the relationship between concentration and price adjustment. In these quantitative tests we shall employ the 1963 and 1971 concentration ratios as well as the Herfindahl indices.

In chapter 4 we were led to the prediction that λ is positively related to concentration. However, in our model, the way in which concentration influenced search costs - the latter being the critical factor in determining the rate of price adjustment - was not particularly general. Consequently, we shall not attempt to derive an explicit functional form linking λ and concentration based on our theoretical result. To specify such an equation directly from the model would render our hypothesis unduly restrictive. Thus whilst concentration remains the key explanatory variable in the equation, the preferred functional form was determined empirically.

It should be noted that our theory defined the lower limit of λ to be zero. Nevertheless, we expect λ_i to be positive irrespective of the level of concentration and consequently we included a constant term in the regression equations. The constant term represents an estimate of the mean rate of adjustment across industries in the sample when the level of concentration is at its minimum.

As will be discussed further below, we expect significant differences in the adjustment coefficients of the engineering and non-engineering industries because of the longer gestation period from input purchases to final deliveries in engineering sectors. To capture these differences we included a dummy variable in the equations, taking the value of 1 when i is an engineering sector and 0 otherwise.

As was previously stated, our estimates of λ relate to the 1963-1974 period, but our indicators of concentration relate to specific years within that period. Thus while each estimate of λ represents an average over this time, the concentration measures do not. Yet changes in concentration could influence λ since the latter may vary within each industry over time. Therefore, where the data permitted, we included changes in concentration as an additional explanatory variable in the equations on empirical rather than theoretical grounds. Our regression specification was as follows:-

$$(3) \quad \lambda_i = A + b_1 CR_{it} + b_2 (CR_{it+\theta} - CR_{it}) + b_3 ED_i + u_i$$

$$b_1 > 0; \qquad b_2 > 0; \qquad b_3 < 0$$

where CR_{it} is the concentration ratio of industry i in period t and ED_i is the engineering industry dummy. The relationship between concentration and the rate of adjustment was also estimated by transforming the variables into a semi-log, a log-linear, and a quadratic functional specification. In this way we were able to compare the goodness of fit of the linear and non-linear relationships. The quadratic specification was included in order to test for the presence of a turning point in the relationship.

The ordinary least squares estimates of equation (2) for the industry sample revealed much the same degree of negative serial correlation as that which was present in the results reported in the previous section. Since the implications for estimation bias are identical, only the generalised least squares results will be considered here.(1)

These results are reported in tables 6.5 and 6.6, and it is immediately apparent that serial correlation is no longer present in any of the regressions. The industry sample was divided into engineering and non-engineering groups on account of our a priori expectation that the respective adjustment coefficients come from two distinctly different populations. The results supported our hypothesis. The mean adjustment coefficient of the engineering industry group was .3490, whilst that of the non-engineering group was .6215. The statistical significance of this difference in the means was confirmed by a t-test (t = 2.2876).

From table 6.5 it can be seen that the constant term was in no case significantly different from zero, a result which is consistent with our expectation. The price index of materials and fuel had a statistically significant impact on output price adjustments in every one of the

---

(1) The ordinary least squares results are reported in appendix tables A.3 and A.4.

Table 6.5 Price Adjustment Equations: Engineering Industries. Dependent Variable ΔWPI_t

Generalised Least Squares Estimates

MLH	Industry Description	Constant	$\Delta PIMF_t$	ΔULC_t	ΔWPI_{t-1}	R^2	F(3,41)	h	ρ
332	Metal Working M-T	-0.3165 (1.2349)	0.4508 (7.4005)	0.0829 (0.7129)	0.7137 (7.4814)	0.8979	120.23	-0.2274	-0.3052
333	Pumps, Valves and Compressors	-0.0757 (-0.3579)	0.1977 (5.8769)	0.2749 (3.5830)	0.6622 (7.6123)	0.8683	90.07	-0.1437	-0.4019
339/1	Mining Machinery	0.0131 (0.0802)	0.1281 (4.0446)	0.1358* (2.5614)	0.7074 (8.3059)	0.8131	59.46	-0.0796	-0.3663
361	Electrical Machinery	-0.2649 (-1.2490)	0.1079 (3.7952)	0.2328 (2.6495)	0.8249 (8.2066)	0.8640	86.82	-0.3433	-0.3819
362	Insulated Wires and Cables	-0.3685 (-0.6337)	0.3551 (12.9345)	0.0668 (0.4153)	0.6942 (11.5047)	0.8302	66.83	-0.3851	-0.4619
363	Telegraph and Telephone Apparatus	-0.2067 (-0.3988)	0.1601 (1.6704)	0.4496* (3.1273)	0.5286 (3.9969)	0.4475	11.07	-0.0204	-0.2960
365/2	Broadcast Receiving Equipment	-0.9320 (-0.6269)	0.1113 (2.4327)	0.0482 (1.0448)	0.3946 (2.0595)	0.4586	11.58	†	-0.2154
368	Domestic Electrical Appliances	0.1715 (-1.2547)	0.1405** (4.1957)	0.1090 (2.1190)	0.6398 (6.8627)	0.8319	67.65	-0.2441	-0.1750
369	Other Electrical Goods	-0.2717 (-1.1548)	0.1261 (3.9299)	0.2348 (2.7536)	0.6932 (6.1086)	0.7442	39.75	-1.0606	-0.4025

Notes: * ΔULC_{t-1} ; ** $\Delta PIMF_{t-1}$

† h statistic not calculable

t-ratios are given in parentheses

WPI: Wholesale Price Index
PIMF: Price Index of Materials and Fuel
ULC: Unit Labour Costs
h: Durbin's Statistic adjusted for lagged dependent variable
ρ: Estimated serial correlation parameter

Table 6.6 Price Adjustment Equations: Non-Engineering industries. Dependent Variable ΔWPI_t

Generalised Least Squares Estimates

MLH	Industry Description	Constant	$\Delta PIMF_t$	ΔULC_t	ΔWPI_{t-1}	R^2	F(3,41)	h	ρ
272/1	Pharmaceutical Chemicals	-0.1096 (-0.3473)	0.1375 (1.8500)	0.3378 (4.2513)	0.6123 (4.2376)	0.6345	23.73	-0.1485	-0.2937
272/2	Pharmaceutical Preparations	-0.0857 (-0.8878)	0.1097 (4.9669)	0.0659 (2.2282)	0.7811 (7.8281)	0.8637	86.60	†	-0.2539
274	Paint	-0.0557 (-0.3352)	0.3023 (8.6588)	0.1898* (2.7492)	0.6067 (10.0357)	0.8551	80.64	-0.2055	-0.8772
411	Man-made Fibres	-1.0059 (-5.1227)	0.4179 (10.5900)	0.5767 (8.7805)	-0.0093 (-0.1436)	0.8912	111.93	-0.0860	-0.1509
414	Woollen and Worsted	0.3595 (1.4408)	0.3752 (10.4533)	0.2016 (2.2324)	0.3752 (5.5757)	0.8513	78.27	-0.0737	-0.7249
419	Carpets and Rugs	0.1609 (0.5761)	0.3598 (4.9855)	0.2322 (2.4764)	0.4382 (4.1072)	0.6443	27.76	0.1364	-0.2881
422/1	Household Textiles	0.1588 (0.6135)	1.0843 (11.4343)	-0.0654 (-0.8456)	-0.1286 (-1.3223)	0.8996	122.44	0.1526	-0.2770
461	Bricks and Refractory Goods	0.0418 (0.2283)	0.4205 (11.9723)	0.0289 (0.3606)	0.4986 (6.4394)	0.8912	111.99	-0.4312	-0.4971
462	Pottery	0.1714 (0.5863)	0.3871 (5.5005)	0.2645 (3.3928)	0.3767 (3.5381)	0.7907	51.62	-0.0297	-0.0698
469/1	Abrasives	0.2372 (0.3573)	0.8477 (5.4791)	0.5215 (3.4699)	-0.3956 (-3.5748)	0.6646	27.08	0.3756	0.0871
473	Bedding	0.0771 (0.3517)	0.4339 (7.5098)	-0.0352 (-0.5947)	0.5998 (7.6105)	0.8422	72.97	-0.2726	-0.5417
483	Manufactured Stationery	-0.2792 (-1.2399)	0.3331 (5.6304)	0.2472 (3.1054)	0.6494 (7.5511)	0.9263	171.72	-0.3170	-0.3802

Notes: * ΔULC_{t-1}

† h statistic not calculable

t-ratios given in parentheses

WPI: Wholesale Price Index
PIMF: Price Index of Materials and Fuel
ULC: Unit Labour Costs
h: Durbin's Statistic adjusted for lagged dependent variable
ρ: Estimated Serial Correlation parameter

nine equations. However, the unit labour cost variable did not perform so well, being statistically significant in six equations only. Its relatively poorer performance may have resulted from the errors of measurement caused by using SIC-order data for MLH industry estimates. The coefficients on the lagged dependent variable, representing the estimates of $(1-\lambda_i)$, were statistically significant and showed a widely diverging partial adjustment structure.

Table 6.6 presents a very similar picture. With only one exception the constant term in the equations was not significantly different from zero. The single exception was the Man-made fibres industry equation in which the constant term was negative and statistically significant. We would explain this result in terms of the influence of technical progress on output prices. It is well known that this industry has experienced considerable technical innovation during our estimation period, both in product specification and production methods. This technological trend is therefore reflected in a downward trend of output prices, although in the remaining industries it was adequately captured through the allowance made in labour costs for the growth of productivity.(1)

As in table 6.5,the price index of materials and fuel had a statistically significant impact on output price changes in all twelve equations and unit labour costs in nine equations only. The partial adjustment coefficients of this sample displayed considerable variability and in two cases they were insignificantly different from zero implying instantaneous price adjustment i.e. $\lambda = 1$. One interesting result was that the estimated coefficient for the Abrasives industry was negative and statistically significant thus implying that λ was significantly greater than one - its theoretical upper bound. The

---

(1) It should be noted that our unit labour cost index was based on an SIC-order, and not an MLH level of aggregation.

industry is highly concentrated and therefore this result may be explained in terms of rapid price adjustments which reflect full or over compensation for cost increases based on inflationary expectations.

Having estimated the adjustment coefficients we are now able to relate them to concentration. However, it should be emphasised that the estimates of λ are based on a period when the trend was one of increasing inflation. Hence our coefficients apply essentially to upward movements in prices. Tables 6.7 and 6.8 report the 1968 mean concentration ratios, the partial adjustment coefficients, and the respective rankings for the engineering and non-engineering industries. The correlation coefficients are given at the bottom of the tables. The figures in brackets represent the unweighted mean concentration ratios and their corresponding rankings.

Taking the engineering industries sample first in table 6.7, it can be seen that the rank correlation coefficient based on the weighted means was .6500 and hence was in accord with our hypothesis. The coefficient based on the unweighted means was somewhat smaller at .6000. Furthermore, both correlation coefficients were statistically significant at the 5% level, as testified by the z-ratios.

Turning next to the non-engineering industry sample in table 6.8, it can be seen that the coefficients of rank correlation based on the weighted and unweighted means were, respectively, .5839 and .5717. Both coefficients were statistically significant at the 5% level.

From these preliminary results and notwithstanding our reservations concerning the 1968 measures of concentration, the hypothesis of a positive association between concentration and rate of price adjustment appears to be given some support. A more precise,

Table 6.7 : 1968 Concentration Ratios, Adjustment Coefficients and Rankings: Engineering Industries

MLH	Industry Description	1968 Mean Concentration Ratios (%)	Industry Structure Ranking	Partial Adjustment Coefficient	Adjustment Ranking
363	Telephone & Telegraph	97.2 (98.2)	1 (1)	.4714	2
362	Insulated Wires & Cables	87.2 (89.3)	3 (2)	.3058	5.5
365/2	Broadcast Receiving Equipment	89.6 (84.6)	2 (3)	.6054	1
368	Domestic Electrical Appliances	81.4 (78.5)	4 (4)	.3602	3
369	Other Electrical Goods	74.7 (73)	5.5 (5)	.3068	5.5
361	Electrical Machinery	75.5 (71.2)	5.5 (6)	.1751	9
339/1	Mining Machinery	59.1* (59.1)*	7 (7)	.2926	7
333	Pumps, Valves, Compressors etc.	40.1 (40.2)	8.5 (8.5)	.3378	4
332	Metal Working Machine Tools	40 (39.2)	8.5 (8.5)	.2863	8

Rank Correlation Coefficient: weighted means: 0.6500 (1.8385)
unweighted means: 0.6000 (1.6971)

Notes: * denotes a concentration ratio specific to the industry as defined by the three or four digit classification in the left hand column of the table. Figures in brackets refer to the unweighted mean concentration ratios and their corresponding rankings. Figures in brackets under the correlation coefficients denote z ratios. The weights used in calculating the mean concentration ratios were the values of sales by product groups published in the Census tables. Rankings which do not appear as whole numbers occur where two industries are given equal rank.

Source: Report on the Census of Production 1968. Summary Tables H.M.S.O. 1974.

Table 6.8 : 1968 Concentration Ratios, Adjustment Coefficients and Rankings: Non-Engineering Industries

MLH	Industry Description	1968 Mean Concentration Ratios (%)	Industry Structure Ranking	Partial Adjustment Coefficient	Adjustment Ranking
411	Man-made Fibres	100* (100)*	1 (1)	1.0000	2.5
469/1	Abrasives	88.8 (88.3)	2 (2)	1.3956	1
462	Pottery	76 (80.7)	3 (3)	.6233	4.5
461	Bricks & Refractory Goods	61 (62.5)	4.5 (4)	.5014	7
272/1	Pharmaceutical Chemicals	61* (61)*	4.5 (5)	.3877	10
274	Paint	53.8 (57.8)	6 (6)	.3933	9
419	Carpets & Rugs	51.7 (51.7)	7 (7)	.5618	6
473	Bedding & Soft Furnishing	45.1* (45.1)*	8.5 (8)	.4002	8
414	Woollen & Worsted	40.7 (39)	10 (10)	.6248	4.5
422/1	Household Textiles	44.7 (39)	8.5 (9)	1.0000	2.5
272/2	Pharmaceutical Preparations	34.9* (34.9)*	11.5 (11.5)	.2189	12
483	Manufactured Stationery	35.2* (35.2)*	11.5 (11.5)	.3506	11

Rank Correlation Coefficient: weighted means: 0.5839 (1.9366)

unweighted means: 0.5717 (1.8961)

Notes: * denotes a concentration ratio specific to the industry as defined by the three or four digit classification in the left hand column of the table. Figures in brackets refer to the unweighted mean concentration ratios and their corresponding rankings. Figures in brackets under the correlation coefficients denote z ratios. The weights used in calculating the mean concentration ratios were the values of sales by product groups published in the Census tables. Rankings which do not appear as whole numbers occur where two industries are given equal rank.

Source: Report on the Census of Production 1968. Summary Tables H.M.S.O. 1974.

quantitative analysis of this relationship follows as the next step.

However, before proceeding we should draw attention to the following points. First, our correlation test was based on concentration ratios measured at a specific point in time. No allowance was made for the potential effect of changes in concentration on the partial adjustment coefficients. This is particularly relevant in the context of the results in table 6.8. In the case of the Household Textiles industry there was an extremely large discrepancy between the adjustment and concentration rankings. This would indicate a non-positive association between concentration and the rate of adjustment for this industry, but the discrepancy may stem from the fact that since 1968 there have been many important mergers in this industry. These mergers and the associated changes in industrial structure may have influenced the rate of adjustment over time. Therefore, the 1968 concentration ratio would be a poor indicator of industry structure where considerable change had taken place. On the other hand, many mergers occurred in industries which were already highly concentrated prior to their incidence. In these sectors the observed changes in concentration during this period will therefore be small.(1)

Nevertheless, in the regression analysis which follows, changes in concentration will be included as an additional explanatory variable in order to estimate their influence, if any, on the rate of adjustment. Moreover, section 6.4 below will examine in some detail the specific effect of important mergers on the price adjustment process. The analysis will attempt to identify any structural breaks

(1) For example, the weighted mean concentration ratio for the Domestic Electrical Appliances industry rose from 75.4% in 1963 to 81.4% in 1968 even though some important mergers took place in this sector.

in the adjustment process which may have taken place during the estimation period.

In addition, this period saw two important phases when Government institutions designed to regulate and control price increases were set up. We refer to the National Board for Prices and Incomes created by the Labour Government in 1965 and abolished in March 1971, and the Price Commission which was set up by the Conservative Government in 1973. There were also two periods of statutory prices and incomes standstill, the first following the sterling crisis of 1966 and the second under stage I of the Counter-Inflation programme which lasted from November 1972 until April 1973. Nevertheless, under both standstill phases price increases were allowed where firms experienced rapid increases in cost.

It is not clear, however, in what way the impact of these institutions and statutory regulations will influence our empirical findings. It is commonly believed that price controls operate more effectively in concentrated industries because the monitoring activity of price controlling institutions is facilitated when relatively few firms account for a large part of the industry's output.

It is clear that within each industry the rate of price adjustment can be partially controlled by these institutions. Yet it is not possible to capture their direct effect in our analysis. However, if the hypothesis mentioned above is correct then should the empirical results indicate a positive relationship between λ and concentration, the validity of the findings would be strengthened. This will be so because such a result would suggest that the activity of price controlling institutions is not as effective in delaying oligopolistic price increases as market fragmentation is in delaying those of competitive firms.

We now turn to the regression analysis linking concentration with the rate of price adjustment. The regression results based on the linear specification are reported in table 6.9. Five alternative equations were estimated using different measures of concentration. In equations (1) and (4) the concentration change during the 1963-1968 period was included as an additional explanatory variable.

Taking equation (1) first, we note that the constant term was positive but not statistically significant. The 1963 concentration ratio had a positive and statistically significant effect on the rate of price adjustment (λ). The estimated coefficient implies that for every percentage point increase in concentration the partial adjustment coefficient will increase by 0.0075. This is a plausible order of magnitude. The change in concentration between 1963 and 1968 was statistically insignificant from zero, although it had the expected i.e. positive sign. As will be discussed further below, this result suggests that the concentration change during this period was either too small or that its relatively long lag means that its influence on the adjustment rates could not be quantified with our data. The engineering industry dummy gave a negative and statistically significant coefficient thus confirming our earlier prediction. This coefficient shows that on average, the adjustment rate in engineering sectors is considerably lower than in non-engineering sectors.

Equation (2) presented a very similar picture. Again, the constant term was positive but not statistically significant. The coefficient on the 1968 concentration ratio was 0.0076 - almost identical in size to the coefficient on the 1963 concentration ratio - and was also statistically significant at the 5% level.

Table 6.9 Partial Adjustment and Industrial Structure*

Dependent Variable: Partial Adjustment Coefficient (λ)
Linear specification. Twenty one industries sample

Explanatory Variables	(1)	(2)	(3)	(4)†	(5)†
Constant	0.1782 (1.0662)	0.1852 (1.1614)	0.3141 (2.3464)	0.5191 (5.9815)	0.5180 (6.2056)
CR_{63}	0.0075 (2.9143)				
$[CR_{68}-CR_{63}]$	0.0091 (1.1433)				
CR_{68}		0.0076 (3.0069)			
CR_{71}			0.0066 (2.6734)		
H_{63}				2.1453 (2.3395)	
$[H_{68}-H_{63}]$				2.3986 (1.1611)	
H_{68}					2.1913 (2.7774)
Engineering Dummy	-0.3821 (-3.4144)	-0.3775 (-3.5339)	-0.3549 (-3.2526)	-0.3649 (-3.2346)	-0.3630 (-3.3638)
R^2	0.4770	0.4756	0.4361	0.5175	0.5171
F Statistic	5.17	8.16	6.96	5.36	8.57

* t-ratios are given in parentheses.

CR_{63} 1963 industry concentration ratio, being a weighted mean (weighted by sales) of component concentration ratios published in the Report on the 1968 Census of Production H.M.S.O. 1974.

CR_{68} 1968 industry concentration ratio derived in the same manner as CR_{63} using the same data sources.

CR_{71} 1971 industry concentration ratio by MLH groups published in the Summary tables of the 1971 Census of Production. H.M.S.O. 1976.

H_{63} Estimate of the 1963 Herfindahl index calculated by M. Waterson from employment data published in the 1968 Census Report. H.M.S.O. 1976.

H_{68} Estimate of the 1968 Herfindahl index compiled in the same way as H_{63}.

† In regression (4) and (5) two sample observations were omitted (MLH 365/2 and 483) because the Herfindahl index was unavailable for these industries.

In equation (3), the key explanatory variable was the 1971 concentration ratio which, unlike the 1963 and 1968 measures, was not an estimate but applied directly at MLH level of aggregation. It is therefore interesting to note that the coefficient on this variable was not only positive and statistically significant, but at 0.0066 it was not much smaller than the corresponding coefficients obtained in equations(1) and (2). This result would suggest that the relationship between concentration and the rate of adjustment is independent of minor differences in the measurement of concentration.

As a further test of the hypothesis we regressed the adjustment coefficients on M. Waterson's estimates of the Herfindahl index of concentration for 1963 and 1968. The results are reported in columns (4) and (5) of the table. The coefficient on H_{63} was positive and statistically significant. However at 2.1453 it was much larger than the coefficients obtained when using the concentration ratios. This can be explained by reference to the fact that the Herfindahl index is measured on a scale between zero and one, whilst the concentration ratio may range from just above zero to one hundred. As for equation (1), the coefficient on the change in the Herfindahl index (H_{68} - H_{63}) was positive but not statistically significant.

Looking at equation (5) we note that the coefficient on H_{68} was almost of equal size to the one on H_{63}, and was statistically significant.

The results obtained for the engineering industry dummy coefficients were remarkably consistent in the five equations. They were negative and statistically significant in every case, and were restricted to between -0.3549 and -0.3821. The F ratios confirmed the statistical significance of the regressions.

The semi-log regressions reported in table 6.10 gave as good a statistical fit as that of the linear specification. The coefficients on all the concentration ratios were statistically significant at the 5% level, and those in equations (1) and (2) indicated that every percentage point increase in the concentration ratio raises the partial adjustment coefficient by 1¼ percent. As before, the concentration change did not have a discernable impact on the speed of adjustment.

Turning to the log-linear results reported in table 6.11, it would appear that, although broadly similar, these regressions did not provide as high a degree of explanatory power as either the linear or the semi-log equations. In particular, the Herfindahl measures of concentration no longer had a statistically significant impact on the rate of adjustment and, furthermore, in equations (3), (4), and (5) the significance of the regressions, as measured by the F statistic, was much reduced.

Finally, the quadratic functional form did not yield statistically significant estimates of the relationship between concentration and the rate of adjustment. Since this specification is clearly inappropriate, the results will not be reported here.[1]

To sum up, our results indicate that a consistently positive and significant relationship exists between industrial concentration and the rate of price adjustment. The results are given added support by the fact that the relationship is invariant with respect to the type of concentration index which was used and the year in which it was measured.

However, our findings raise one important question. Given that the 1963-1974 period saw considerable merger activity leading to substantial increases of concentration in some sectors, how can this be reconciled with our findings that changes in concentration did not

(1) These results are reported in the appendix.

Table 6.10 Partial Adjustment and Industrial Structure*

Dependent Variable: Partial Adjustment Coefficient(Log λ)
Semi-Log Specification. Twenty one industries sample

Explanatory Variables	(1)	(2)	(3)	(4)†	(5)†
Constant	-1.3272 (-4.7193)	-1.3253 (-4.9463)	-1.0745 (-4.6557)	-0.7517 (-5.1328)	-0.7535 (-5.3498
CR_{63}	0.0125 (2.8732)				
$\left[CR_{68}-CR_{63}\right]$	0.0129 (0.9594)				
CR_{68}		0.0125 (2.9606)			
CR_{71}			0.0102 (2.3762)		
H_{63}				3.1849 (2.0585)	
$\left[H_{68}-H_{63}\right]$				3.5983 (1.0323)	
H_{68}					3.2599 (2.4490)
Engineering Dummy	-0.6771 (-3.5961)	-0.6759 (-3.7653)	-0.6285 (-3.3405)	-0.6716 (-3.5275)	-0.6684 (-3.6707)
R^2	0.4933	0.4933	0.4265	0.5250	0.5247
F Statistic	5.52	8.76	6.69	5.53	8.83

* t-ratios are given in parentheses.

CR_{63} 1963 industry concentration ratio, being a weighted mean (weighted by sales) of component concentration ratios published in the Report on the 1968 Census of Production H.M.S.O. 1974.

CR_{68} 1968 industry concentration ratio derived in the same manner as CR_{63} using the same data sources.

CR_{71} 1971 industry concentration ratio by MLH groups published in the Summary tables of the 1971 Census of Production. H.M.S.O. 1976.

H_{63} Estimate of the 1963 Herfindahl index calculated by M. Waterson from employment data published in the 1968 Census Report. H.M.S.O. 1976.

H_{68} Estimate of the 1968 Herfindahl index compiled in the same way as H_{63}.

† In regressions (4) and (5) two sample observations were omitted (MLH 365/2 and 483) because the Herfindahl index was unavailable.

Table 6.11 Partial Adjustment and Industrial Structure*

Dependent Variable: Partial Adjustment Coefficient (Log λ)
Log-linear specification. Twenty-one industries sample

Explanatory Variables	(1)	(2)	(3)	(4)†	(5)†
Constant	-3.5729 (-3.2126)	-3.5630 (-3.3495)	-2.2841 (-2.6046)	-0.2017 (-0.5095)	-0.1253 (-0.3473)
Log CR_{63}	0.7414 (2.7075)				
Log $[CR_{68}/CR_{63}]$	0.7771 (0.9842)				
Log CR_{68}		0.7399 (2.7981)			
Log CR_{71}			0.4473 (1.9357)		
Log H_{63}				0.1249 (1.1746)	
Log $[H_{68}/H_{63}]$				0.3443 (0.5439)	
Log H_{68}					0.1337 (1.3022)
Engineering Dummy	-0.6709 (-3.5155)	-0.6693 (-3.6628)	-0.6049 (-3.0935)	-0.6264 (-3.0037)	-0.6396 (-3.1599)
R^2	0.4750	0.4750	0.3764	0.4202	0.4091
F Statistic	5.13	8.14	5.43	3.62	5.54

* t-ratios are given in parentheses

CR_{63} 1963 industry concentration ratio, being a weighted mean (weighted by sales) of component concentration ratios published in the Report on the 1968 Census of Production H.M.S.O. 1974.

CR_{68} 1968 industry concentration ratio derived in the same manner as CR_{63} using the same data sources.

CR_{71} 1971 industry concentration ratio by MLH groups published in the Summary tables of the 1971 Census of Production. H.M.S.O. 1976.

H_{63} Estimate of the 1963 Herfindahl index calculated by M. Waterson from employment data published in the 1968 Census Report. H.M.S.O. 1976.

H_{68} Estimate of the 1968 Herfindahl index compiled in the same way as H_{63}.

† In regression (4) and (5) two sample observations were omitted (MLH 365/2 and 483) because the Herfindahl index was unavailable.

influence the adjustment coefficient, λ? We would suggest that this result is due, in part, to the deficiencies in the measurement of concentration change. Since our variable only covered the period from 1963 to 1968, any mergers which took place after 1968 and which had influenced market structure would not have been captured. Consequently, it is likely that we would have generally underestimated the degree of concentration change by using this variable in the regression analysis. In addition, several mergers took place in industries which were already highly concentrated prior to the merger. Hence in these sectors the observed change in concentration could be very small, notwithstanding the incidence of significant mergers. It is also possible that the time lag between changes in concentration and its impact on λ may be fairly long, so that it may take several years before the effect of an increase in concentration leads to a change in the price adjustment behaviour of the industry.

However, since the relationship between the level of industrial concentration and the rate of adjustment was clearly established, the effect of mergers which lead to increases in concentration must ultimately be to increase the rate of price adjustment. Nevertheless, in the subsequent section we shall investigate the influence of mergers on the price adjustment process. In particular, we shall examine whether any significant structural breaks in the price adjustment process of a sub-sample of industries can be traced back to important mergers. This question is of interest because mergers could have an impact on industrial pricing behaviour which would not be observed if concentration increased more gradually through internal growth. Furthermore, in view of the fact that the rate of inflation had accelerated rapidly in the latter part of our estimation period, a structural break in the adjustment process could have taken place simply on account of newly formed inflationary expectations.

6.4 Structural Breaks in the Price Adjustment Process

If we accept that mergers are positively related to increases in industrial concentration[(1)], then it is of some interest to examine whether mergers which have a significant impact on industrial structure also lead to an eventual change in the price adjustment process. In this section we shall attempt to identify and analyse structural breaks in the price adjustment equations of industries which have experienced significant merger activity.

An essential prerequisite for this analysis was a measure of changes in industrial concentration, over selected time periods, which would permit the identification of mergers with a significant impact on the industry. In effect, the major problem with this analysis lay in the inadequacy of the data. The problem arose because of the non-comparability of the two sets of concentration ratios at our disposal. The ones available were for the years 1963, 1968, 1970, and 1972, and so would appear to provide considerable scope for measuring changes in concentration. However,the 1963 and 1968 concentration ratios are not comparable with those for 1970 and 1972 because the two sets are based on different levels of industry aggregation. Thus we can evaluate changes in concentration between 1963 and 1968 or 1970 and 1972, but cannot do so between 1968 and 1970 or 1972.

The non-comparability of these concentration ratios restricted our ability to measure changes in industrial structure which could be used to identify significant mergers. As most of the important mergers which affected the industries in our sample occurred in the late 1960's and early 1970's, if we were to use the 1963-1968 concentration changes

---

(1) For evidence see Hart,Utton, and Walshe (1973), and Stoneman (1976).

as the basis for identifying significant mergers we would run the risk of omitting important ones which took place after 1968.

To safeguard against such omissions we selected our sample of industries on the basis of two criteria:- the incidence of important mergers in terms of the asset size of the taken-over firm, and the change in concentration from 1963 to 1968 and 1970 to 1972.

The sample which was selected for our analysis comprised six industries, four of which had experienced important mergers, with an increase in concentration of at least 20% during the estimation period. The remaining two industries did not belong to this category but were included for purposes of comparison, that is, in order to ascertain whether any structural breaks are confined to industries with significant mergers or are due to more general factors such as changes in the overall rate of inflation.

To test for the significance of structural breaks in the equations we used the familiar "Chow Test"(1). The data set was divided in two parts so as to obtain two separate estimates of the price adjustment equations in the two sub-periods. If the first period comprised m observations and the latter period n observations, then the F statistic which was used to test for structural breaks was defined as:

$$F(p,\ m+n-2p) = \frac{\left[\sum e^2_{m+n} - \sum e^2_m - \sum e^2_n\right] / p}{\left[\sum e^2_m + \sum e^2_n\right] / \left[m+n-2p\right]}$$

where $\sum e^2_{m+n}$, $\sum e^2_m$, and $\sum e^2_n$ are the residual sum of squares of the regressions using m+n, m, and n observations respectively. The number of estimated parameters in the equations is given by p. Since F has an "F" distribution with p and m+n-2p degrees of freedom, if it exceeded the critical value for a predetermined level of confidence we rejected the null hypothesis of

(1) For a discussion of this methodology see Johnston (1972), Chapter 6.

no structural break in favour of the alternative hypothesis. This result would indicate that the adjustment process in the post-merger period was significantly different from that in the first period.

The industries selected for the analysis, with their respective concentration changes are reported in table 6.12 below.

Table 6.12 Changes in Concentration

MLH	Industry Description	1963-1968 % Concentration Change*	1970-1972 % Concentration Change†
422/1	Household Textiles	20	83
339/1	Mining Machinery	40	10
368	Domestic Electrical Appliances	8	20
411	Man-made Fibres	0	-3
419	Carpets and Rugs	21	14
469/1	Abrasives	6	-3

* Based on the weighted concentration ratios reported in the appendix.

† From the Report on the Census of Production 1970 and 1972, Summary Tables.

The Household Textiles industry, traditionally fragmented, was subjected to a large number of mergers during the 1960's, a particularly significant one being that between Courtaulds and Ashton Brothers Ltd., in the second quarter of 1968. The value of the assets taken over was £11.2 million.

In the Mining Machinery industry the important merger was between the Dowty Engineering group and Anderson-Morris Ltd. in the second quarter of 1970, with the assets acquired valued at £19 million. However, by far the largest merger in our sample was that between GEC and English Electric in the Domestic Electrical Appliance industry. The value of the assets taken over was £417 million. This merger took place in the second quarter of 1968.

The Man-made Fibres and Abrasives industries, although highly concentrated, did not experience any significant takeovers or changes in concentration during the relevant period. In the Carpets industry an important merger took place in the second quarter of 1969 between the Guthrie Corporation and James Templeton Ltd. with the assets of the acquired company valued at £14.1 million.

Before reporting our results it should be stressed that our analysis did not aim at identifying the quarter when the structural change took place, but only at determining whether one had occurred in the post-merger period.

Our methodology was therefore to allow a period of six months after the merger had taken place as the basis for splitting up the sample period. Thus, in the case of the Mining Machinery industry with an important merger in the second quarter of 1970, the early estimation period was from 1963 I to 1970 IV and the post-merger estimation period was from 1971 I to 1974 IV. For those industries which had not experienced any significant mergers the estimation period was divided as follows: 1963 I to 1968 IV and 1969 I to 1974 IV.

In tables 6.13 and 6.14 both ordinary and generalised least squares estimates are reported on account of the potential bias associated with serial correlation in the regressions. However, only the estimated coefficients on the lagged dependent variable are reported since the remainder are of no relevance to this analysis. As these coefficients represent the estimates of $(1 - \lambda_i)$ the implied values of λ_i are also reported in the tables.

From table 6.13 it can be seen that the adjustment coefficient of the Household Textiles industry increased from .4873 in the early period to 1.279 - a value which is greater than its theoretical upper bound of unity. This suggests that during the post-merger period the price adjustment process in this industry involved an element of overcompensation for cost increases based, perhaps, on inflationary expectations.

Table 6.13 Split Period Estimates of the Price Adjustment Coefficients: Variable Periods

Industry Description	Estimation Period	ΔWPI_{t-1} (OLSQ)	ΔWPI_{t-1} (GLSQ)	Implied λ	F(4,36)
Household Textiles (422/1)	1963 I-1968 IV	0.4571 (2.9697)	0.5127 (4.0822)	.4873	4.77*
	1969 I-1974 IV	-0.2889 (-1.9749)	-0.2791 (-2.4387)	1.2791	
Mining Machinery (339/1)	1963 I-1970 IV	0.5889 (3.8189)	0.6625 (4.5731)	.3375	2.97*
	1971 I-1974 IV	0.5886 (3.1189)	0.7276 (6.6859)	.2724	
Domestic Electrical Appliances (368)	1963 I-1968 IV	0.0028 (0.0139)	0.0880 (0.4284)	1.000	0.32
	1969 I-1974 IV	0.6496 (4.2928)	0.6613 (4.4191)	.3387	
Man-made fibres (411)	1963 I-1968 IV	-0.1022 (-0.4672)	0.3549 (1.8089)	.6451	4.64*
	1969 I-1974 IV	-0.0349 (-0.5022)	-0.0365 (-0.5230)	1.000	
Carpets and Rugs (419)	1963 I-1969 IV	-0.0649 (-0.2941)	-0.0616 (-0.2732)	1.000	2.85*
	1970 I-1974 IV	0.2963 (1.9224)	0.3197 (2.3105)	.6803	
Abrasives (469/1)	1963 I-1968 IV	-0.0196 (-0.0934)	0.2654 (1.4514)	.7346	0.79
	1969 I-1974 IV	-0.3969 (-2.4533)	-0.4367 (-2.7532)	1.4367	

Notes: t - ratios in parentheses

* denotes a significant F statistic at the 5% level.
WPI: Wholesale Price Index.
OLSQ: Ordinary Least Squares Estimates.
GLSQ: Generalised Least Squares Estimates.

What is curious, however, is that the adjustment coefficient of the Mining Machinery, Domestic Electrical Appliances and the Carpets industry actually decreased in the later estimation period. This drop was from .3375 to .2724 in the case of the Mining Machinery industry, and from unity to .3387 and .6803 in the case of the Domestic Electrical Appliances and the Carpets industry respectively. Furthermore, the F ratio was statistically significant at the 5% level in two out of the three cases.[1]

These results are puzzling and contrary to our a priori expectations, but they are open to an alternative interpretation. Consider, for example, the change in the Wholesale Price Index of Domestic Electrical Appliances during the 1963 to 1974 period. Between 1963 and 1966 this index rose by only 2.6% and, similarly, by only 2.1% in the next three years. By contrast, between 1969 and 1971 the index rose by 17.6%, and from 1972 to 1974 by 24.2%. It is clear from these figures that the rate of price increase from 1963 to 1968 was extremely small compared to the rate prevailing in the 1969 to 1974 period. Hence the period stretching from 1969 onwards represents a very different history of price movements than the six years which preceded it. The marked divergence of the rate of price increase between the two periods was also evident in the Mining Machinery industry, and to a lesser extent in the Carpets industry.

Therefore, these results may be explained by suggesting that, regarding these three industries, the absolute magnitude of the desired rate of

---

(1) The F test concerns the break in the overall relationship and is not specific to individual parameter changes. However, since a productivity trend was incorporated in the equations, we would not expect structural breaks to be associated with changes in the cost coefficients.

adjustment in the 1963 - 1968 period was so small that the costs of instantaneous adjustment were negligible and that therefore firms in these industries found it expedient to pass on the entire increase in price during the current quarter. Although this type of behaviour was not specifically discussed in the theoretical analysis it is intuitively plausible that for extremely small changes in the rate of price adjustment the costs of adjustment are effectively ignored. Thus in these situations a distributed lag structure of price adjustments would not be observed since changes would be effected instantaneously. It is clear that the type of behaviour described above is consistent with the estimated coefficients which were obtained.

Turning to the Man-made Fibres industry it can be seen from table 6.13 that the estimated adjustment coefficient rose from .6451 to 1.000 and that the F ratio was statistically significant thus indicating a structural break in the equation. The coefficient of the Abrasives industry rose from .7346 in the early period to 1.436 in the later period but the F ratio was not statistically significant at the 5% level.

What may be concluded from the results presented so far? The results do not reveal a consistent set of reactions to merger activity and changes in the rate of inflation. Furthermore, in view of the fact that three industries in our sample showed a reduction of the adjustment coefficient in the later period it is evident that the sample observations used to obtain the pre- and post-merger adjustment coefficients are not strictly comparable. This is so because the early estimation period was characterised by relatively moderate price increases whilst in the later period all the industries in the sample had moved into the double figure inflation phase. The marked difference in economic conditions in the two periods may influence the adjustment behaviour of firms and consequently render our comparisons somewhat unreliable. More specifically in periods of rapid inflation firms may increase their partial adjustment coefficient so as to shorten the lag between cost and price increases. They would do so because in times of inflation,lagging behind cost increases could lead to severe short-run liquidity problems. Therefore it may be that the observed increases in the adjustment coefficients in table 6.13 are influenced to a greater extent by the overall rate of inflation in the 1969-1974 period than by the incidence of mergers.

It is particularly interesting that the two industries which exhibited an increase in the adjustment coefficient and had a statistically significant F ratio were characterised by either a high increase in concentration (Household Textiles) or an existing high level of concentration (Man-made Fibres). This evidence suggests that in conjunction with inflation both a high level as well as a large increase in concentration have a similar effect in reducing the lag of adjustment.

In order to improve the comparability of our adjustment coefficients we re-estimated the equations by splitting up the period from 1968 to 1974 into one extending from 1968 I to 1971 II and the other from 1971 III to 1974 IV. This sample breakdown was used for all six industries because the small number of observations did not permit changing the estimation period to take into account the date of a merger. Nevertheless, since the earliest relevant merger was that of GEC and English Electric in the second quarter of 1968 we can be confident that the adjustment coefficients estimated from 1968 I to 1971 II would not have been influenced by the merger. More important, since both estimation periods lie within the higher inflation phase. the comparison of adjustment coefficients will not be subject to those problems of interpretation discussed above.

From table 6.14 in which the results based on these alternative estimation periods are reported, it can be seen that the adjustment coefficient of the Household Textiles industry rose from unity to 1.402 - i.e. to a value greater than its theoretical upper bound. In addition the F ratio indicated a statistically significant structural break in the equation. Moreover, since the estimate based on the 1968 I to 1971 II period was unity this indicates that the process of increasing the rate of price adjustment was already well under way by the early 1970's. The increase in the coefficient to a value greater than unity may be explained in terms of inflationary expectation and an attempt by the industry to increase price-cost margins over time, so that when met with cost increases prices were raised by a greater amount than that required to restore former price-cost margins.

In contrast to the results based on the 1963 - 1968 and 1969 - 1974 estimation periods, the adjustment coefficient of both the Mining Machinery and the Domestic Electrical Appliances industry did rise somewhat as can be observed in table 6.14, although the F ratios did not indicate a structural break in the equations. Since the mergers took place in 1970 I and 1968 II respectively, these results would suggest that the mergers did not lead to a significant change in the price adjustment process. Furthermore they suggest that these industries did not respond to an accelerating rate of inflation with a substantial increase of their adjustment coefficients. They also support our hypothesis regarding the observed drop in the coefficients

Table 6.14 Split Period Estimates of the Price Adjustment Coefficients:

(1968 I - 1971 II, 1971 III - 1974 IV)

Industry Description	Estimation Period	ΔWPI_{t-1} (OLSQ)	ΔWPI_{t-1} (GLSQ)	Implied λ	F(4,18)
Household Textiles (422/1)	1968 I-1971 II	-0.4799 (-0.1550)	0.1846 (0.7528)	1.000	3.35*
	1971 III-1974 IV	-0.3699 (-2.0358)	-0.4023 (-5.6413)	1.4023	
Mining Machinery (339/1)	1968 I-1971 II	0.6931 (3.0769)	0.7585 (4.5066)	0.2415	2.43
	1971 III-1974 IV	0.5658 (3.0819)	0.7358 (5.5480)	0.2642	
Domestic Electrical Appliances (368)	1968 I-1971 II	0.5618 (2.1683)	0.8991 (6.2733)	0.1009	2.34
	1971 III-1974 IV	0.6769 (3.7975)	0.7366 (4.1605)	0.2634	
Man-made fibres (411)	1968 I-1971 II	-0.0476 (-0.2305)	0.4439 (2.2265)	.5561	2.25
	1971 III-1974 IV	-0.0441 (-0.5313)	-0.0445 (-0.5110)	1.000	
Carpets and Rugs (419)	1968 I-1971 II	-0.2972 (-0.9787)	-0.2699 (-0.9879)	1.000	1.48
	1971 III-1974 IV	0.3547 (1.6501)	0.3505 (1.9294)	.6495	
Abrasives (469/1)	1968 I-1971 II	-0.1838 (-0.5789)	0.0370 (0.1349)	1.000	1.63
	1971 III-1974 IV	-0.5337 (-2.7816)	-0.5198 (-2.4737)	1.5198	

Notes: t - ratios in parentheses

* denotes a significant F statistic at the 5% level.
WPI: Wholesale Price Index.
OLSQ: Ordinary Least Squares Estimates.
GLSQ: Generalised Least Squares Estimates.

reported in table 6.13 which was discussed above.

The coefficient of the Man-made Fibres industry increased from .5561 to unity and that of the Abrasives industry from 1.000 to 1.5798. By contrast, the coefficient of the Carpets industry fell from 1.000 to .6495 in the later period. In all three cases the F ratio was not statistically significant at the 5% level. It is interesting to note that both the Man-made Fibres and the Abrasives industry are highly concentrated while the Carpets industry is not. Thus the two increases in the adjustment coefficient were observed in concentrated industries whilst the only case of a decrease in the coefficient was in an industry of moderate concentration.

In conclusion, the following tentative inferences may be drawn. On the one hand it would appear that concentrated industries are more successful at raising their rate of price adjustment in times of inflation, as suggested by the results in table 6.14. Also, the adjustment coefficients of the Household Textile industry in table 6.13 would suggest that rapid increases in concentration through merger activity may have the same effect on the adjustment process. On the other hand the results in table 6.13 would also indicate that when faced with very small increases in prices, firms may abandon the partial adjustment process in favour of full price increases in the current period. The rationale for such behaviour is that since in such circumstances the costs of price adjustment are negligible, they may therefore be ignored by firms which are contemplating an adjustment of price.

More interesting, perhaps, are the inferences which may be suggested regarding the impact of price-controlling institutions. In relation to the Conservative Government's anti-inflation programme, which also included the creation of the Price Commission in 1973, the results reported in table 6.14 suggest that concentrated industries are more successful at withstanding the pressure of the Price Commission than those of low concentration. This finding is particularly significant because it has often been suggested that the Price Commission is much more effective in controlling price increases of the industrial giants than those of their lesser brethren. This hypothesis is based on the premise that it is easier to monitor an industry where a few large sellers account for a large proportion of the industry's output. However, the evidence presented in this section, whilst by no means definitive, casts doubt on this notion.

Hence, to sum up, our results indicate that important mergers may, after some time, raise the rate of price adjustment by facilitating a more co-ordinated pattern of reactions by firms to economic change. However, two important caveats should be entered. First, the rather small sample of six industries does not permit any significant generalisation to be made. Therefore, any inferences which might be drawn from the structural breaks analysis must be treated with caution and considered tentative. Second, although the evidence did indicate that mergers may be associated with a change in the price adjustment behaviour of the industry, it was also found that an overall increase in the rate of inflation appeared to have a comparable if more consistent influence on the price adjustment process.

6.5 Concluding Remarks

This chapter was concerned with detailed empirical tests of the hypotheses which were developed in chapter 4. In addition, we examined the stability of the price adjustment process over time by looking closely at a sub-sample of industries. This was carried out in order to identify any structural breaks in the adjustment process which could be associated with important influences on industry pricing behaviour, notably the impact of significant mergers and marked accelaration in the overall rate of inflation.

The first part of the empirical analysis in this chapter was concerned with the influence of short-run changes in demand on price adjustment. This involved estimating a price adjustment equation for each of the 21 industries in the sample. The dependent variable in these equations was the wholesale price index and the explanatory variables were the price index of materials and fuel, the unit labour costs index, the indicator of demand, and the lagged dependent variable. However, capital costs were excluded from the equations, but this omission can be justified on theoretical grounds since the familiar prediction in the orthodox theory of the firm is that fixed costs are of no relevance to price adjustments.[1]

The essential innovation of this analysis lay in the construction of the demand indicator which was based on an input-output methodology previously suggested by Lustgarten (1975). By using this approach we attempted to overcome the usual problems of estimation and measurement which have bedevilled many empirical studies in the past. One of these is the difficulty of measuring demand rather than output which represents the joint demand and supply decision. The other, and potentially more severe estimation problem, arises from the simultaneity bias which occurs when the demand variable appears on the right hand side of the adjustment equation.

---

(1) It should be noted that capital costs were not included in most of the empirical pricing studies which were reviewed in the previous chapter.

Notwithstanding the improved data specifications, the regression results were somewhat ambiguous and could have several interpretations. On the one hand the results appeared to support our hypothesis concerning the influence of search costs on the adjustment of price to changes in demand. For in fifteen out of twenty-one equations the coefficients obtained were insignificantly different from zero. But on the other hand, the preponderance of coefficients with the wrong i.e. negative sign, of which five were statistically significant, suggests that our demand proxy may not be free from bias and that therefore the results should be considered tentative.

The sources of bias most likely to be present were first, the measurement of output as values of deliveries deflated by a price index and second, the possibility of the demand variable picking up the effect of changes in the rate of production on short-run labour productivity. A priori it is not possible to determine the extent to which these effects might be present, but our findings suggest that their influence cannot be discounted.

One other possible interpretation of these results needs to be considered. In the empirical analysis it was assumed that fixed costs do not enter the firm's short-run pricing decision, and similarly, that only the long-run trend in labour productivity is used to establish unit labour costs. However, if the firm's pricing decision was based on short-run average costs, then changes in fixed costs would affect short-run price adjustments. Thus the negative coefficients could be explained in terms of the relationship between changes in output and changes in average fixed costs, the latter falling with increases in output. The demand variable may be picking up the influence of average costs on price adjustments through the effects of changes in output.[1] However, this interpretation is somewhat speculative as it is based on unorthodox assumptions about pricing behaviour of firms.

Only in one equation did the demand variable have the expected i.e. positive sign and was statistically significant. It was also noted that this coefficient related to an industry of high concentration, and that therefore it was consistent with our hypothesis. However, the findings gave no insight into the relationship between the degree of price adjustment to changes in demand and industrial market structure. Further results must await the availability of more reliable data.

More definitive were the results concerning the relationship between market structure and the rate of price adjustment. A set of estimated partial adjustment coefficients was obtained from the price equations, one for each industry in the sample. A rank correlation test was then carried out using the 1968 concentration ratios. The results indicated a positive and statistically significant association between the two variables. Consequently, as a second step in the analysis, the relationship was tested by means of ordinary least squares regressions which enabled estimates of the quantitative impact of concentration on the rate of adjustment to be derived. Five concentration measures were used, covering the three years 1963, 1968 and 1971. These different measures were used because our estimates of λ were averages for the 1963-1974 period, yet the concentration ratios referred to specific years within that time span. By using the three annual concentration ratios we were able to test the sensitivity of the hypothesised relationship to changes in the measurement of concentration.

(1) Agarwala and Goodson (1970), have suggested this interpretation in their empirical study.

Linear, semi-log, log-linear and quadratic functional specifications were tested in this analysis. The results of the latter were not reported in this chapter on account of the poor statistical fit which was obtained. The other functional forms performed considerably better. In the linear specification the coefficients on the concentration ratios for 1963, 1968 and 1971 and on the Herfindahl indices (1963 and 1968 only) had the expected, i.e. positive sign and were statistically significant at the 5% level. The results also indicated that the rate of price adjustment in the engineering sectors was significantly lower than in the non-engineering sectors. The semi-log regressions gave equally robust results, but those of the log-linear specification, while generally similar, did not give as good a statistical fit as the other two functional forms.

Thus, the empirical analysis came out in support of our hypothesis by indicating a positive and statistically significant impact of concentration on the rate of price adjustment. Of particular interest was the finding that the relationship was neither sensitive to the type of concentration index used nor the year in which it was measured.

In addition, the results cast doubt on the proposition that concentrated oligopolies are slow in adjusting prices, at least for the United Kingdom, and consequently they do not appear to support the administered prices hypothesis. The findings suggest that in times of rising costs, industrial concentration could aggravate the inflationary problem by speeding up the rate of price increases. The resulting policy implications will be discussed in the next chapter.

One important aspect of the results was the finding that changes in concentration, measured between 1963 and 1968, did not have a significant impact on the partial adjustment coefficient λ. It was suggested that this may be due to problems of measurement which would be particularly severe if the time lags involved were greater than our data permitted us to capture. Hence in the last section of this chapter we examined the stability of the price adjustment process over the estimation period.

The analysis consisted of a test aimed at identifying structural breaks in the pricing behaviour of six industries which were selected from our twenty-one industry sample. The potential influence of important mergers in a number of industries was also investigated as part of this structural breaks analysis.

Three related findings may be tentatively put forward. First, when prices are rising very slowly firms may abandon the partial price adjustment process in favour of full adjustment during the current period. This finding was interpreted in terms of the insignificance of search costs under such a regime. Second, a series of important mergers may have an impact, after a time, on the price adjustment process as attested by the pricing behaviour of the Household Textiles industry. Third, in times of inflation firms may raise their rates of price adjustment in an effort to keep up with rising costs. Of special interest here was the finding that concentrated industries do this to a larger extent than unconcentrated industries. This raises important policy implications with regard to price controlling institutions but these will not be explored here.

However, since these results are based on a small sample of industries, the inferences made above should be considered tentative.

By way of conclusion we suggest that the results concerning the impact of market structure on the rate of adjustment constitute the most significant empirical finding of this thesis. The other empirical tests were subject to important caveats relating to their statistical reliability and should therefore be considered suggestive rather than definitive. It should also be emphasised that since the 1963-1974 estimation period included downturns as well as upturns in the level of economic activity, the empirical findings should be relatively free from the usual problems of sensitivity to the time period used for estimation. The link between the findings reported in this chapter and those of the studies purporting to support the administered prices hypothesis, together with any resulting policy implications, will be discussed in the final chapter of this thesis.

Chapter 7

CONCLUSIONS, POLICY IMPLICATIONS, AND FURTHER RESEARCH

7.1 A Summing-up

The main concern of this thesis, as outlined in the introductory chapter, lay in relinquishing the traditional assumptions about the pricing behaviour of market participants thereby permitting a more realistic scenario of price adjustment to be explored. The essence of our approach was to consider a fairly general pricing model in which the potential action of rivals and the information costs associated with monitoring their behaviour are explicitly introduced into the model. Our analysis revealed the existence of a potential asymmetry in the price response induced by changes in marginal cost compared to the one induced by changes in demand. The rationale for this asymmetry was suggested to be the unequal incidence of search costs associated with the price adjustment decision. The search for relevant information is required because the emergence of disequilibrium does not, by itself, reveal the values of the key parameters which are necessary for equilibrium to be restored. However, we are not suggesting in this thesis that adjustments to short-run variations in demand will be effected entirely through changes in output levels, whilst those occasioned by changes in costs will fall solely on price. What we are suggesting is that adjustments to demand are attenuated relative to those stemming from changes in cost.

In the beginning of this thesis it was pointed out that our analysis shared a common theme with the theoretical controversy known as the "new view" of Keynes and the administered prices hypothesis. In both of these the question of adjustment to disequilibrium in the modern industrial economy features prominently. However, we went a step further to propose a broad synthesis between the two controversies and to argue that our own conclusions were consistent with both views provided the market setting within which firms operate was explicitly defined. The administered prices hypothesis emphasises the sluggishness of industrial prices in the context of cyclical variations in economic activity, whilst the "new view" of Keynes gives a central role to the reversal of price and quantity adjustment velocities. Yet both of these lines of thought are consistent with the proposition that search costs may play an important part in attenuating price adjustments to changes in demand. Thus the approach adopted in this thesis is characterised by what Coddington (1976) has described as:

> ". . . refocusing the market theory on disequilibrium states whilst retaining the standard choice-theoretic foundations".(1)

Before summing up the empirical results it should be remembered that the analysis focused on the costs associated with price adjustment, whilst those attendant to changes in the level of output were admittedly neglected. Furthermore, our results related specifically to the direct influence of short-run changes in demand on output price adjustments. Without dwelling on this issue, it was recognised that demand changes may influence price adjustments in the longer-run through indirect effects on production costs.(2) We also recognised the fact that search costs would be partially determined by the time available for information gathering, so that they may be considerably reduced in the long-run.

---

(1) Coddington (1976), p. 1271.

(2) For example, by raising prices of raw materials.

In chapter 4 we examined the comparative statics and the dynamics of price adjustment on the basis of the dual-decision process. The question of price dynamics was analysed through a partial adjustment model, from which the optimal rate of price adjustment over time could be derived. The key result of this analysis was based on the influence of information costs associated with the monitoring of the rate of price adjustment among rivals. Without information about these rates of adjustment, dynamic co-ordination of prices in the industry would not be possible. From the partial adjustment model it was possible to infer that industrial concentration facilitates a co-ordinated pattern of price reactions because it reduces the search costs associated with the monitoring process. This conclusion is contrary to the administered prices hypothesis since it implies that oligopolists will be far from sluggish in their price response compared to that of firms in competitive or low-concentration industries. How can these conflicting predictions be reconciled in view of their allegedly common underpinnings? The reason lies in the fact that there is a fundamental difference between low-concentration industries and perfectly competitive industries, which Means calls "market-dominated". In perfectly competitive markets of the Walrasian type, price adjustment is costless and instantaneous. But in low-concentration industrial markets this is not the case. Thus industrial concentration raises the rate of price adjustment, but this does not mean that concentrated industries adjust more rapidly than perfectly competitive markets in which clearing systems exist. Therefore the basis for Means' controversial assertion rests on a comparison of oligopolistic and perfectly competitive markets.(1) Hence the paradoxical feature

(1) This is in sharp contrast to our own analysis which specifically linked the rate of adjustment to the level of industrial concentration.

associated with Means' hypothesis stems from the lack of precision in the definition of administered and market-dominated prices.

The empirical findings may be summed up as follows: regarding the question of demand, the results were broadly in keeping with expectations, although they were not conclusive. There remained a problem of interpretation on statistical grounds, and it was suggested that it arose from the traditional difficulties associated with the measurement of demand. More conclusive empirical findings must therefore await improvements in the data.

The results of the empirical tests concerning the dynamics of price adjustment were more definitive. Using different measures of industrial concentration, we found that in every case the estimated partial adjustment coefficient λ was positively related to the concentration variable. Furthermore, the relationship was marked by a consistently high level of statistical significance. Hence the empirical evidence provided considerable support for our hypothesis and indicated that oligopolists in highly concentrated industries adjust prices more rapidly in response to cost increases than firms in more fragmented industries.

The evidence concerning the short-run impact of mergers and changes in the rate of inflation on the dynamics of adjustment was somewhat ambiguous. We found some indication that significant merger activity and increases in inflation caused the rate of price adjustment to increase, but the pattern of reactions was by no means conclusive or systematic. Furthermore, the results must be treated with caution on account of the small, six-industry sub-sample on which they were based.

Another finding, which was incidental but interesting nevertheless, was that increases in the rate of price adjustment occurred either in rapidly concentrating industries or in those which were already highly concentrated. This result raises important questions concerning the effectiveness of price controlling institutions, but these will be discussed in the next section of this chapter.

By far the most significant implication of the results is that the factors which lead to increases in concentration in the long-run, will also lead to higher rates of price increases with important consequences for the management of inflation.

7.2 Some Policy Implications

Our findings have relevant implications for the question of monopolies and mergers and the contiguous problem of inflation management. In the past, these policy questions have not always been linked to one another, although it has recently been suggested that the inflationary experience of the United Kingdom economy may be associated with increasing industrial concentration.(1)

The policy implications to which we refer concern the impact of market structure on the inflationary process, but they relate to an aspect of this issue which hitherto has not been discussed. We are not suggesting that concentration is a prime cause of inflation, for there is no evidence in this research that would support this view. However, the results did point to an association of industrial concentration with a faster response to cost increases. The implication of this result is that in an economy where product market power is considerable, the short-run rate of inflation stemming from an exogenously determined increase in primary input prices may be substantially higher than if industrial concentration was less pronounced. However, in the context of inflation management, it could

(1) See Cowling and Waterson (1976).

be argued that if primary input price increases have to work their way through the economy until a new equilibrium is ultimately obtained, then the authorities will be indifferent as to whether the adjustment process is completed in the short or medium term. But on the other hand a case could be made for suggesting that the authorities would not be indifferent between a two-figure inflation rate over a one year period and a single-figure inflation rate over a two or three year period. For policy makers would be anxious to contain inflation to levels below what might be termed the "stability threshold".(1) What we imply by this concept is that if the rate of inflation should exceed a critical level which is determined by social and political considerations of the time, the consequences for efficient management of the economy could be significant. Thus if inflation exceeds the stability threshold trade unions may become particularly militant in their efforts to protect their members' real disposable income and wage demands may escalate to the point where further price increases are inevitable. In addition, holders of sterling balances, anticipating the foreign exchange pressures which would accompany a rise in inflation, may decide to pull out of sterling thus placing an added burden on the domestic exchange rate. If the authorities then allow the rate to fall relative to other currencies, the pressures of inflation will be further aggravated through the resulting domestic price increases of imported raw materials and fuels.

On the basis of this reasoning we would suggest that the authorities are unlikely to be indifferent between a high short-run rate of inflation and a lower rate which extends over a longer period.

---

(1) Until the early 1970's an inflation rate in excess of 10% per annum would have been considered unacceptable.

Their preference is likely to be for the latter, for the reasons which were outlined above.

Thus we would contend that our findings introduce an added dimension to policies concerned with the control of monopolies and mergers. For as has been indicated, a high level of market concentration makes the attainment of the short-run price stability objective less likely in the face of exogenous rises in input costs. This is because market concentration leads to a faster rate of adjustment in the industry, thereby raising the rate of inflation in the short-run. Thus, from a policy viewpoint, it is important that proper attention should be given by the relevant authorities to this aspect of mergers and the increased level of concentration to which they lead, as well as to the high levels of concentration which already exist in a number of important sectors.(1)

In this context it is interesting to observe that no evidence was found to indicate that the activity of the National Board for Prices and Incomes and the Price Commission was effective in restraining the rate of price increases in concentrated sectors relative to those in more competitive sectors. Furthermore the structural breaks analysis indicated that concentrated industries were more successful at raising their rates of adjustment in response to increases in inflation than more fragmented industries. These findings cast some doubt on the effectiveness of Government institutions for price control in comparison with what could be achieved in a more competitive economy.

Regarding incomes policy, the implication of our findings is that by raising the short-run rate of inflation, market concentration will ultimately undermine attempts to conduct an effective incomes policy, unless rigid price controls are imposed and import prices stay relatively stable.

---

(1) See Monopolies Commission report on Parallel Pricing, (1973).

It should be pointed out that our analysis did not indicate what the specific economy-wide effect of higher partial adjustment coefficients in concentrated industries might be on the short-run inflation rate in terms of the time paths of output prices. To this end we must allow for the interaction of different rates of adjustment through the intermediate chains of production. Hence the answer to this question requires extensive research which is beyond the scope of this thesis.(1)

Our findings also have implications for general demand management and particularly for policies aimed at increasing the growth rate of the United Kingdom economy. Since 1973, when the fixed exchange rate regime was abandoned in favour of the fully-floating type, it has been held that the balance of payments would no longer impose an effective constraint on the rate of growth in the United Kingdom. Previously, an acceleration of the rate of economic expansion was accompanied, within a short space of time, by a balance of payments crisis which invariably led to excessive speculation culminating in a devaluation of the domestic currency.(2) Thus the constraint operating on economic growth, namely the balance of payments, was seen to arise from the authorities' commitment to a fixed-rate convertibility of sterling. Once this commitment was removed the road to economic expansion would be wide open, particularly through increases in exports.

However, the recent British experience has shown that other problems stand in the way of achievement of this policy objective. The balance of payments has ceased to be an effective constraint on economic growth, and furthermore, the authorities may, within limits, actively

---

(1) A research methodology will be proposed in section 7.3 of this chapter

(2) One such crisis took place in November 1967.

support the downward floating of the exchange rate as this would increase the competitiveness of British manufactures, thereby leading to a salutary increase in the demand for exports. But a fall in the exchange rate will raise the price of imported raw materials in terms of the domestic currency. Thus, before long, the associated cost increases will be fed through to final output prices, and the initial competitive advantage induced by the exchange rate adjustment may be partially or even totally wiped out.

Thus the effectiveness of export-led growth policies, which rely on the international competitiveness of British manufactures, depends largely on the relative speed of adjustment of the demand for exports and final output prices. For if the adjustment of export demand is slow relative to the adjustment of output prices, the effect of rising import costs will largely offset the effect of competitive exchange-rate policies. Therefore the implication of our analysis is that since increased concentration has the effect of raising the speed of price adjustment, increases in concentration are incompatible with policies designed to improve the competitiveness of British exports in order to stimulate economic growth.

The above discussion also implies that the old balance of payments constraint has re-appeared under a new guise. For rapid expansions in economic activity, which spill over into an increased demand for imports, will cause a downward pressure on the exchange rate which will aggravate the inflationary problem via the increased costs of imports.(1) It is therefore questionable whether the former constraints on rapid economic growth in the United Kingdom have been removed. Our

---

(1) This is essentially the monetarist view of inflation. An extensive survey is given in Flemming (1976). An analysis of the U.K. experience is given in Williamson and Wood (1976).

reasoning suggests that a mere substitution has occurred, of the threat of inflation in place of the former balance of payments constraint.

To conclude, we would sum-up our policy implications as follows. Under a freely floating exchange rate regime industrial concentration is likely to aggravate the problem of inflation and is therefore inconsistent with policies aimed at economic stability. Our evidence suggests that inflation is likely to come from exogenous increases in primary input prices and not directly from excess demand, since the estimated price response to these pressures appeared uncertain and unsystematic. However, excess demand may have an indirect effect if it spills over into the demand for imports causing a downward movement in the domestic exchange rate which raises import prices.

The analysis indicated that market concentration will make the attainment of inflation management, incomes policy and growth objectives more elusive on account of the associated rates of price adjustment. Current policies towards monopolies and mergers should be critically re-appraised in light of these findings.

7.3 Directions for Further Research

The empirical results which have been discussed in chapter 6 suggest a number of spheres in which the present research may be usefully extended.

The first stems from the desirability of additional analysis of the influence of demand on price adjustments, since the results obtained in this thesis were not conclusive. However, as has already been pointed out, the problems with this analysis were due largely to deficiencies in the data, and specifically with reliable measures of demand. Therefore further research in this area will depend on the availability of improved data.

Another useful extension of the research would consist of enlarging the sample of industries on which the findings concerning market structure and the rate of price adjustment were based. Although these results were generally robust and hence fairly conclusive, an increase in the sample of industries, particularly by adding some from the SIC-orders which were not included in the present analysis, would considerably enhance the significance of the results.

But perhaps the most valuable extension of the present research would involve an analysis of the economy-wide effects of the higher rates of price adjustment which are associated with industrial concentration. In this thesis we derived quantitative estimates of the influence of concentration on rates of adjustment in individual sectors. But since every sector in the economy is linked to others through the intermediate chain of production, it is clear that high rates of adjustment in any one sector will affect industries which use that sector's output as inputs in their own production processes. Thus in an economy where the degree of interconnectedness in production is high, the potential for interaction among the different rates of adjustment will be considerable. Hence, a high rate of price adjustment in a concentrated industry will carry an influence beyond its own relative weight in the vector of final output prices. It will have economy-wide repercussions by influencing the adjustment process of industries which use its output in production, these in turn will influence other user industries and so the process will go on.

From the above discussion it should be clear that an input-output approach, which explicitly allows for sectoral interdependence in production, is the most appropriate for our purpose. Furthermore, the partial price adjustment model which was developed in chapter 4 can be neatly extended to cover any number of related industries, as will be demonstrated below. The elements of the proposed dynamic input-output model are as follows:

$[A]$: The matrix of input-output coefficients. An element a_{ij} shows the amount of commodity i used in the production of one unit of commodity j.

$[B]$: The matrix of primary input coefficients. This is the matrix of required inputs whose prices are determined outside the model.

$[\hat{\lambda}]$: Diagonal matrix of partial adjustment coefficients. Each element λ_i shows the proportion of the relevant price change which is passed on in the current period. $(0<\lambda_i \leq 1)$.

$[\Delta P_t]$: Vector of endogenously determined price changes in period t.

$[\Delta V_t]$: Vector of primary input price changes in period t.

The single sector price adjustment equation can now be extended to the whole economy:

$$(1) \qquad [\Delta P_t] = [\hat{\lambda} A'][\Delta P_t] + [\hat{\lambda} B'][\Delta V_t] + [I - \hat{\lambda}][\Delta P_{t-1}]$$

For a two-sector economy this may be expressed as:

$$(2) \quad \Delta P_{1t} = \lambda_1 a_{11} \Delta P_{1t} + \lambda_1 a_{21} \Delta P_{2t} + \lambda_1 b_{11} \Delta V_{1t} + \lambda_1 b_{21} \Delta V_{2t} + (1-\lambda_1) \Delta P_{1t-1}$$

$$(3) \quad \Delta P_{2t} = \lambda_2 a_{12} \Delta P_{1t} + \lambda_2 a_{22} \Delta P_{2t} + \lambda_2 b_{12} \Delta V_{1t} + \lambda_2 b_{22} \Delta V_{2t} + (1-\lambda_2) \Delta P_{2t-1}$$

Thus in each sector, the current period adjustment is determined by the current period change in intermediate and primary input prices, plus the change in intermediate input prices in the previous period.

Equation (1) may be re-arranged so that ΔP_t appears on the left hand side only:

$$(4) \qquad \left[\Delta P_t\right] = \left[I - \hat{\lambda}A'\right]^{-1}\left[\left[\hat{\lambda}B'\right]\left[\Delta V_t\right] + \left[I - \hat{\lambda}\right]\left[\Delta P_{t-1}\right]\right]$$

Equation (4) represents a modified, dynamic version of the conventional dual to the static Leontief system.[1] The inverse $\left[I - \hat{\lambda}A'\right]^{-1}$ is analogous to the static Leontief inverse $\left[I - A'\right]^{-1}$, so that subject to the usual stability conditions, it represents the infinite series $I + \lambda A' + \left[\hat{\lambda}A'\right]^2 \ldots$ In the same way, this inverse captures the total, that is, the direct and indirect effects of price changes affecting any one sector on all other sectors. If we call this inverse $\left[A\right]^*$, then an element a^*_{ij} denotes the total direct and indirect effect of a price change originating in sector i on the output price change of sector j, given the degree of industrial interdependence in the economy and the partial adjustment mechanism of each sector. In this manner, the proposed model allows for the interaction suggested above amongst the price adjustments of different but interdependent industries. The system could be used to trace or simulate the ripple effects of primary input price increases on output price movements which work their way through the economy.

More specifically, the proposed dynamic model could be used to estimate the length of time after which changes in primary input prices are reflected in a new vector of output prices. It may also be used to test the sensitivity of output price trajectories to differences in the partial adjustment rates of key industrial sectors, and the effect of different dynamic price policies of nationalised industries. Finally, it could be used to estimate the overall impact of concentration on the

---

(1) For an analysis of this system see Dorfman, Samuelson and Solow (1958).

short-run rate of inflation following input price increases.

To conclude, we would suggest that although the proposed dynamic input-output model is subject to the usual restrictive assumptions of linearity and rigidly specified pricing behaviour, it nevertheless provides a useful method of analysis of the way in which input price increases are transmitted through interconnected sectors of the economy.

APPENDIX

Table A1 The Absorption Matrix for 1963 in Coefficient Form

	Commodity \ Industry	1	2	3	4	5	6	7
1	Agriculture, Forestry and Fishing	.0209	0	.1944	.0002	.0232	0	0
2	Mining and Quarrying	.0016	.0143	.0041	.1428	.0217	.0091	.0021
3	Food, Drink and Tobacco	.1306	.0008	.1600	0	.0109	0	.0001
4	Coal and Petroleum Products	.0149	.0087	.0044	.0217	.0242	.0449	.0037
5	Chemical and Allied Industries	.0496	.0090	.0358	.0287	.2302	.0116	.0179
6	Metal Manufacture	.0013	.0377	.0049	.0016	.0083	.3143	.1139
7	Mech. Instrmnt. Electl. Engineering	.0126	.0533	.0105	.0073	.0224	.0367	.1598
8	Shipbuilding and Marine Engineering	.0023	0	0	0	0	.0005	0
9	Vehicles	.0026	.0022	.0005	.0004	.0008	.0078	.0022
10	Metal Goods n.e.s.	.0125	.0050	.0162	.0024	.0206	.0111	.0409
11	Textiles	.0039	.0065	.0020	0	.0046	.0002	.0032
12	Leather, Fur, Clothing and Footwear	.0002	.0037	.0000	0	.0006	.0001	.0003
13	Bricks, Pottery, Glass, Cement etc.	.0023	.0085	.0066	.0006	.0077	.0123	.0104
14	Timber, Furniture etc.	.0020	.0149	.0027	.0002	.0025	.0013	.0067
15	Paper, Printing and Publishing	.0003	.0037	.0305	.0014	.0194	.0028	.0108
16	Other Manufacturing Industries	.0047	.0176	.0048	.0006	.0092	.0021	.0120
17	Construction	.0119	.0173	.0033	.0005	.0044	.0019	.0021
18	Gas, Electricity and Water	.0072	.0313	.0082	.0199	.0241	.0300	.0110
19	Transport Services n.e.s. Distribution	.0986	.0742	.0975	.0379	.1319	.0898	.0882

Source: A programme for Growth (1974), vol. 12.
London: Chapman and Hall

Table A1 (continued)

8	9	10	11	12	13	14	15	16	17	18	19	
0	0	0	0	.0445	.0005	0	0	.0398	0	.0004	.0009	1
.0011	.0024	.0022	.0081	.0018	.0922	.0012	.0118	.0058	.0110	.2093	.0033	2
0	0	0	.0004	0	.0010	0	0	.0001	0	0	.0022	3
.0027	.0049	.0048	.0030	.0017	.0303	.0035	.0043	.0048	.0067	.0536	.0128	4
.0090	.0099	.0179	.0362	.0141	.0331	.0199	.0283	.1724	.0200	.0064	.0070	5
.0991	.1206	.2570	.0000	.0012	.0068	.0075	.0060	.0075	.0444	.0171	.0011	6
.0722	.0836	.0230	.0130	.0086	.0370	.0068	.0155	.0190	.0366	.0480	.0143	7
.1584	0	0	0	0	0	0	0	0	0	0	.0048	8
.0007	.1884	.0013	.0006	.0002	.0026	.0003	.0009	.0023	.0028	.0013	.0138	9
.0762	.0788	.1154	.0019	.0157	.0134	.0241	.0025	.0228	.0181	.0033	.0082	10
.0052	.0077	.0032	.4000	.2669	.0051	.0313	.0072	.0622	.0018	.0007	.0083	11
0	.0012	.0004	.0007	.1115	.0001	.0003	.0008	.0024	0	.0002	.0008	12
.0052	.0052	.0031	.0009	.0003	.0625	.0087	.0004	.0037	.1067	.0060	.0008	13
.0115	.0114	.0023	.0004	.0012	.0064	.2410	.0035	.0078	.0602	.0021	.0020	14
.0016	.0058	.0077	.0061	.0109	.0246	.0107	.2335	.0320	.0063	.0031	.0347	15
.0043	.0316	.0077	.0047	.0196	.0063	.0111	.0081	.0458	.0075	.0016	.0114	16
.0050	.0021	.0020	.0023	.0027	.0014	.0015	.0020	.0017	.1502	.0023	.0088	17
.0129	.0110	.0177	.0111	.0057	.0365	.0071	.0127	.0157	.0030	.0579	.0154	18
0645	.0821	.0969	.0533	.0799	.1344	.0747	.1232	.1010	.0668	.0751	.0910	19

Table A2 The "Makes" Matrix for 1963
(£ million)

	Industry / Commodity	1	2	3	4	5	6	7
1	Agriculture, Forestry and Fishing	1664.0	0	0	0	0	0	0
2	Mining and Quarrying	0	1058.0	3.2	0	0.1	0	0.9
3	Food, Drink and Tobacco	0	0	3176.9	0	19.6	0	0.2
4	Coal and Petroleum Products	0	0	0	649.1	17.6	0	0.2
5	Chemical and Allied Industries	0	1.2	42.0	6.1	1979.0	3.2	5.0
6	Metal Manufacture	0	0.1	0	0	10.8	2411.6	21.0
7	Mech. Instrmnt. Electl. Engineering	0	0	0	0.1	3.4	35.2	4305.0
8	Shipbuilding and Marine Engineering	0	0	0	0	0	0.9	20.1
9	Vehicles	0	0	0	0	0	4.0	90.6
10	Metal Goods n.e.s.	0	0	0	0	6.2	30.0	27.3
11	Textiles	0	0	0	0	6.0	0	1.8
12	Leather, Fur, Clothing and Footwear	0	0	0.1	0	0.2	0	0.2
13	Bricks, Pottery, Glass, Cement etc.	0	5.1	0	0	1.3	0.1	3.7
14	Timber, Furniture etc.	0	0	0	0	0.4	0	1.3
15	Paper, Printing and Publishing	0	0	0	0	0.3	3.4	1.0
16	Other Manufacturing Industries	0	0	0.1	0	10.5	0.4	3.8
17	Construction	0	0.3	0	0	0.2	0.9	12.9
18	Gas, Electricity and Water	0	0	0	97.0	18.4	0	0
19	Transport, Services n.e.s. Distribution	0	0	32.1	0	0	0.2	0
	Total	1664.0	1064.8	3254.3	752.3	2074.1	2490.0	4494.8
	Diagonal element as % of Total	100.0	99.4	97.6	86.3	95.4	96.8	95.8

Source: Department of Applied Economics, University of Cambridge

Table A2 (continued)

8	9	10	11	12	13	14	15	16	17	18	19	
0	0	0	14.0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	3.4	0	0	0	1.2	1.1	0.7	2
0	0	0.0	0.1	0	0.1	1.5	0.2	0.1	0	0	134.3	3
0	0	0	0	0	0.1	0	0	0	0	41.3	0.1	4
0	0.5	0.1	0.8	0.1	3.5	0	0.8	7.0	4.8	9.0	30.2	5
0.3	2.5	38.0	0	0	0.5	0.2	2.6	1.7	0.8	9.3	9.2	6
18.9	40.0	37.5	0.1	0.1	3.0	1.1	0.5	10.0	16.0	0	60.4	7
394.8	1.5	0.1	0	0	0.1	0.2	0	0.2	2.2	0	0	8
3.2	2582.2	12.5	4.1	0.3	0.2	1.4	0.3	2.9	0.1	1.6	16.6	9
0.2	4.5	1276.0	0.6	0.2	0.4	1.6	1.2	5.4	5.8	0	6.4	10
0	0	0.1	2053.3	3.3	0.2	0.3	2.4	3.3	0	0.3	7.8	11
0	0.1	0.1	2.4	989.0	0.1	0.2	0	4.0	0	0	10.0	12
0	0.6	0	2.7	0	725.9	1.0	0.3	0.6	13.8	0.1	5.1	13
0	0.5	3.7	1.6	0.5	1.1	635.6	2.0	1.7	5.0	0	2.8	14
0	0.8	0.8	0.9	0.2	0.5	0.6	1612.9	8.6	0	0.2	11.0	15
0	2.3	1.7	3.2	4.4	0.9	1.9	1.4	745.0	0	0	12.5	16
0.6	0	0.9	0	0	9.7	6.4	0	0.2	3861.0	0	9.9	17
0	0	0	0	0	0	0	0	0	0	1598.6	0	18
0.2	6.4	0	21.9	0	0	0	0	0	0	0	13535.5	19
418.2	2641.7	1371.5	2105.5	998.1	749.6	651.8	1625.5	790.5	3910.6	1661.6	13853.0	
94.4	97.7	93.0	97.5	99.1	96.8	97.5	99.2	94.2	98.7	96.2	97.7	

Table A.3 Price Adjustment Equations Engineering Industries. Dependent Variable ΔWPI_t

Ordinary Least Squares Estimates

MLH	Industry Description	Constant	$\Delta PIMF_t$	ΔULC_t	ΔWPI_{t-1}	R^2	F(3,42)	h
332	Metal-working Machine Tools	-0.2508 (-0.7673)	0.4686 (6.4797)	0.1027 (0.8387)	0.6548 (6.3040)	0.8897	112.95	-2.4816
333	Pumps, Valves, Compressors etc.	0.0823 (0.2855)	0.1558 (3.8221)	0.1953 (2.2167)	0.7311 (7.0445)	0.8535	81.59	-2.3462
339	Mining Machinery	0.0771 (0.3496)	0.1356 (3.3783)	0.2006* (3.7362)	0.5698 (5.3381)	0.7992	55.74	-1.7969
361	Electrical Machinery	-0.1161 (-0.3903)	0.1018 (2.8043)	0.2166 (2.2297)	0.7968 (6.8322)	0.8442	75.58	-3.5239
362	Insulated Wires and Cables	0.0332 (0.0386)	0.3320 (9.5628)	-0.0107 (-0.0528)	0.6640 (8.1783)	0.7906	52.85	-3.0707
363	Telegraph and Telephone Apparatus	-0.1419 (-0.2206)	0.2230 (2.0844)	0.5554* (3.6564)	0.2997 (2.1185)	0.4329	10.69	-1.6683
365/2	Broadcast Receiving Equipment	-0.0692 (-0.3954)	0.1353 (2.6970)	0.0315 (0.6604)	0.3125 (1.5244)	0.4492	11.42	†
368	Domestic Electrical Appliances	-0.1539 (-0.9942)	0.1484** (4.2969)	0.1045 (2.0069)	0.6088 (6.2750)	0.8289	67.84	-1.1880
369	Other Electrical Goods	-0.1564 (-0.4718)	0.1409 (3.4277)	0.3107 (3.2173)	0.5010 (3.7486)	0.7128	34.75	-3.4887

Notes: * ΔULC_{t-1} ; ** $\Delta PIMF_{t-1}$

† h statistic not calculable

t-ratios are given in parentheses

WPI: Wholesale Price Index
PIMF: Price Index of Materials and Fuel
ULC: Unit Labour Costs
h: Durbin's Statistic adjusted for lagged dependent variable

Table A.4 Price Adjustment Equations Non-Engineering Industries. Dependent Variable ΔWPI_t

Ordinary Least Squares Estimates

MLH	Industry Description	Constant	$\Delta PIMF_t$	ΔULC_t	ΔWPI_{t-1}	R^2	F(3,42)	h
272/1	Pharmaceutical Chemicals	-0.0065 (-0.0159)	0.1717 (2.0048)	0.2881 (3.5365)	0.5507 (3.5198)	0.6125	22.13	†
272/2	Pharmaceutical Preparations	-0.0865 (-0.7210)	0.1156 (4.5806)	0.0613 (2.1438)	0.7513 (7.2404)	0.8553	82.78	-1.9609
274	Paint	0.1499 (0.3381)	0.2940 (3.6602)	0.4334* (4.7401)	0.3860 (2.9478)	0.6750	29.08	-8.0642
411	Man-made Fibres	-1.0276 (-4.6976)	0.4180 (9.9697)	0.5927 (9.5182)	-0.0255 (-0.3883)	0.8894	112.62	-0.7807
414	Woollen and Worsted	0.5658 (1.5577)	0.3665 (8.0211)	0.1273 (1.2513)	0.3344 (3.8008)	0.8251	66.03	-2.7007
419	Carpets and Rugs	0.2857 (0.8033)	0.3823 (4.7478)	0.2053 (2.2045)	0.3599 (3.1144)	0.6274	23.58	-1.6296
422/1	Household Textiles	0.1708 (0.5227)	1.0581 (9.8890)	-0.0098 (-0.1231)	-0.1281 (-1.1832)	0.8940	118.07	-1.9657
461	Bricks and Refractory Goods	0.1803 (0.6430)	0.4482 (9.8165)	-0.0198 (-0.2240)	0.4501 (4.7255)	0.8621	87.54	-3.6783
462	Pottery	0.1886 (0.6254)	0.3995 (5.6016)	0.2664 (3.5697)	0.3557 (3.3603)	0.7928	53.58	-0.2855
469/1	Abrasives	0.2656 (0.4484)	0.8508 (5.6356)	0.4889 (3.3013)	-0.3676 (-3.2586)	0.6648	27.76	0.6461
473	Bedding etc.	0.0360 (0.1020)	0.5554 (6.5181)	0.0765 (1.0400)	0.3559 (3.2914)	0.8109	60.04	-1.5800
483	Manufactured Stationery	-0.3068 (-1.0175)	0.3149 (4.8608)	0.2910 (3.4446)	0.6439 (7.0180)	0.9176	155.83	-1.9014

Notes: * ΔULC_{t-1}

† h statistic not calculable

t-ratios are given in parentheses

WPI: Wholesale Price Index
PIMF: Price Index of Materials and Fuel
ULC: Unit Labour Costs
h: Durbin's statistic adjusted for lagged dependent variable

Table A.5

Concentration Indices Used in the Regression Analysis

MLH	CR_{63}	CR_{68}	CR_{71}	H_{63}	H_{68}
363	94.6	97.2	92	0.14510	0.24256
362	91.7	87.2	87	0.13549	0.12469
365	74.1	89.6	70	*	*
368	75.4	81.4	58	0.04447	0.04680
369	67.9	74.7	51	0.03847	0.05010
361	55.2	75.5	54	0.04689	0.07652
339/1	42.2	59.1	64	0.00621	0.00573
333	36.4	40.1	24	0.02055	0.01982
332	34.0	40.0	28	0.02096	0.02532
411	99.9	100.0	98	0.23868	0.20000
469/1	83.5	88.8	77	0.122630	0.17871
462	60.7	76.0	40	0.01729	0.04043
461	50.8	61.0	50	0.01787	0.02761
272/1	53.9	61.0	39+	0.03678	0.03695
274	52.6	53.8	45	0.02965	0.03074
419	42.7	51.7	37	0.03761	0.04553
473	51.4	45.1	34	0.01994	0.02294
414	30.2	40.7	21	0.00940	0.01097
422/1	37.9	44.7	40	0.00835	0.01212
272/2	28.7	34.9	39+	0.03678	0.03695
483	39.2	35.2	35	*	*

Source: CR_{63} and CR_{68} are the estimated percentage concentration ratios for 1963 and 1968 respectively. They are weighted means (weighted by value of sales) of the concentration ratios of individual commodity groups published in the Summary Tables of the Report on the Census of Production, 1968 H.M.S.O. 1974.

CR_{71} is the 1971 concentration ratio at MLH level published in the Report on the Census of Production, 1971. H.M.S.O. 1976.

H_{63} and H_{68} are unpublished estimates of the Herfindahl index of concentration calculated by M. Waterson of the University of Newcastle. They are based on employment data published in the Census of Production Report, 1968. H.M.S.O. 1974.

+ This concentration ratio applies to MLH 272 i.e. Pharmaceutical Chemicals and Preparations industry.

Table A6 : Partial Adjustment and Industrial Structure*

Dependent variable : Partial Adjustment Coefficient (λ)
Quadratic specification. Twenty-one industries sample

Explanatory Variables	(1)	(2)	(3)	(4)†	(5)†
Constant	0.5741 (1.2189)	0.7715 (1.3305)	0.5229 (1.4259)	0.5317 (4.7535)	0.5459 (4.3186)
CR_{63}	-0.0044 (-0.2661)				
$[CR_{63}]^2$	0.0001 (0.6842)				
CR_{68}		-0.0123 (-0.6464)			
$[CR_{68}]^2$		0.0002 (1.0514)			
CR_{71}			-0.0017 (-0.1246)		
$[CR_{71}]^2$			0.0001 (0.6134)		
H_{63}				2.1305 (0.6040)	
$[H_{63}]^2$				0.4207 (0.0269)	
H_{68}					1.1497 (0.3233)
$[H_{68}]^2$					4.4879 (0.3009)
Engineering Dummy	-0.3404 (-3.0955)	-0.3698 (-3.4646)	-0.3478 (-3.1141)	-0.3392 (-2.7839)	-0.3622 (-3.2577)
R^2	0.4519	0.5076	0.4483	0.4741	0.5200
F Statistic	4.67	5.84	4.60	4.51	5.42

* t-ratios are given in parentheses.

CR_{63} 1963 industry concentration ratio, being a weighted mean (weighted by sales) of component concentration ratios published in the Report on the 1968 Census of Production H.M.S.O. 1974.

CR_{68} 1968 industry concentration ratio derived in the same manner as CR_{63} using the same data sources.

CR_{71} 1971 industry concentration ratio by MLH groups published in the Summary tables of the 1971 Census of Production. H.M.S.O. 1976.

H_{63} Estimate of the 1963 Herfindahl index calculated by M. Waterson from employment data published in the 1968 Census Report. H.M.S.O. 1976.

H_{68} Estimate of the 1968 Herfindahl index compiled in the same way as H_{63}.

† In regression (4) and (5) two sample observations were omitted (MLH 365/2 and 483) because the Herfindahl index was unavailable for these industries.

Table A.7

Price Index of Materials and Fuels (Quarterly)

1963 I = 100		Building Materials etc. MLH 469	Paint MLH 274	Metal working Machine Tools MLH 332	Electrical Machinery MLH 361
1963	I	100.0	100.0	100.0	100.0
	II	100.8	99.9	100.3	100.2
	III	100.9	99.9	100.3	100.3
	IV	101.2	100.4	100.8	100.7
1964	I	101.6	100.5	102.5	101.9
	II	101.8	100.4	103.1	103.1
	III	102.3	100.8	103.7	103.9
	IV	104.0	101.4	104.8	106.2
1965	I	104.0	101.9	106.0	107.4
	II	104.5	101.6	106.8	108.5
	III	105.9	101.5	107.0	108.7
	IV	106.1	101.8	107.9	110.7
1966	I	106.1	102.9	110.3	115.2
	II	107.2	103.1	113.1	121.1
	III	107.5	103.1	112.3	119.5
	IV	107.3	102.4	111.7	117.5
1967	I	107.0	102.2	111.2	116.4
	II	106.8	102.1	110.2	113.5
	III	108.7	104.0	111.1	114.2
	IV	110.5	105.5	114.3	120.2
1968	I	112.6	108.4	119.0	129.0
	II	113.0	108.9	117.7	124.7
	III	113.0	108.9	117.5	123.2
	IV	113.3	109.0	118.3	124.3
1969	I	115.1	109.8	120.4	127.9
	II	115.6	110.2	122.6	131.1
	III	116.4	111.5	125.1	135.8
	IV	118.9	112.7	128.8	139.3
1970	I	122.0	114.1	133.5	145.4
	II	124.5	116.2	135.7	148.4
	III	126.4	119.5	134.6	146.3
	IV	130.5	120.7	136.0	146.8
1971	I	134.7	123.4	140.7	148.7
	II	141.2	125.0	145.2	154.9
	III	144.6	128.0	147.2	155.6
	IV	145.0	127.8	147.5	154.5
1972	I	145.9	128.7	148.8	155.9
	II	148.0	130.2	152.1	159.1
	III	149.0	131.9	154.0	160.9
	IV	150.4	134.1	156.6	163.0
1973	I	151.3	135.8	158.8	168.0
	II	153.5	139.7	164.4	177.1
	III	158.1	151.3	171.7	190.7
	IV	162.2	158.6	179.6	204.6
1974	I	178.2	192.0	195.2	230.7
	II	198.3	211.7	217.7	260.0
	III	210.1	222.6	225.2	255.3
	IV	222.8	232.6	233.8	254.7

Table A.7 (continued)

1963 I = 100 Year		Carpets and rugs MLH 419	Manufactured Stationery MLH 483	Broadcast receiving and sound reproducing equipment MLH 365	Bedding and soft furnishings MLH 473
1963	I	100.0	100.0	100.0	100.0
	II	100.5	100.1	100.1	100.2
	III	101.0	100.2	100.3	100.3
	IV	103.1	100.6	101.1	100.8
1964	I	103.9	101.6	103.0	102.3
	II	103.6	102.0	103.9	103.1
	III	104.4	102.2	104.8	104.0
	IV	105.2	102.8	106.3	105.0
1965	I	104.4	104.4	107.5	106.6
	II	104.6	104.6	108.2	107.0
	III	105.1	104.7	110.0	107.5
	IV	105.6	104.8	111.0	107.9
1966	I	106.4	105.3	113.9	109.2
	II	107.8	105.7	115.8	110.4
	III	108.2	105.7	115.6	110.5
	IV	106.9	105.5	115.8	110.2
1967	I	105.4	104.9	116.4	109.5
	II	105.0	105.1	115.4	108.6
	III	103.7	105.2	116.8	108.7
	IV	103.7	105.7	120.8	110.5
1968	I	112.5	112.2	125.2	114.9
	II	113.2	113.7	125.0	115.0
	III	113.8	113.6	125.0	115.4
	IV	116.9	113.8	125.5	116.8
1969	I	111.4	115.8	124.9	118.9
	II	112.2	116.3	127.0	120.4
	III	112.4	118.0	129.8	122.3
	IV	111.8	119.3	132.8	124.1
1970	I	112.6	124.4	136.4	127.0
	II	114.3	125.7	139.8	129.8
	III	115.0	129.2	142.1	130.9
	IV	114.9	130.4	144.1	131.9
1971	I	116.2	134.6	148.4	134.9
	II	119.1	135.5	151.8	138.3
	III	122.1	136.5	153.9	141.1
	IV	123.1	137.0	155.5	141.7
1972	I	127.1	139.3	159.3	144.0
	II	132.2	141.0	162.3	146.7
	III	136.8	142.5	165.7	150.6
	IV	149.5	144.7	169.5	157.2
1973	I	163.0	146.5	172.8	162.4
	II	165.5	149.1	179.5	169.8
	III	173.1	158.9	186.2	184.7
	IV	178.2	164.4	195.1	198.7
1974	I	190.2	184.4	209.5	215.7
	II	194.8	204.7	225.2	228.8
	III	194.6	231.4	238.0	236.3
	IV	197.5	242.4	249.2	237.4
1975	I	201.2	263.9	265.7	241.8
	II	209.2	271.3	274.5	246.2
	III	215.1	278.1	287.2	252.3
	IV	222.9	283.8	294.9	259.2

Table A.7 (continued)

1963 I = 100 Year	Pharmaceuticals MLH 272	Pumps, Valves etc. MLH 333	Mining Machinery MLH 339/1
1963 I	100.0	100.0	100.0
II	100.2	100.5	100.2
III	100.8	100.6	100.4
IV	101.5	101.3	100.7
1964 I	101.4	103.7	102.1
II	101.6	105.8	102.6
III	102.3	107.2	103.0
IV	102.8	109.3	103.7
1965 I	103.3	109.8	104.8
II	103.8	111.0	105.7
III	103.6	111.0	105.9
IV	103.8	113.2	106.5
1966 I	104.6	119.2	108.2
II	105.1	122.1	110.8
III	105.0	118.8	110.6
IV	104.5	118.0	110.2
1967 I	104.2	117.1	109.9
II	104.1	114.4	109.3
III	105.0	115.6	110.1
IV	106.4	121.9	112.2
1968 I	108.9	129.9	115.2
II	109.0	125.4	115.1
III	108.7	124.9	115.0
IV	109.0	126.4	115.5
1969 I	109.8	130.0	116.4
II	110.9	133.8	118.2
III	111.4	138.3	122.0
IV	113.2	141.9	124.3
1970 I	115.1	146.7	129.5
II	116.7	148.7	132.4
III	119.0	145.0	132.8
IV	121.0	144.4	136.1
1971 I	124.7	150.5	139.9
II	126.6	156.2	145.9
III	128.4	157.6	147.8
IV	128.6	157.2	148.0
1972 I	129.0	159.0	149.0
II	130.5	162.6	153.5
III	132.1	164.7	155.1
IV	134.4	167.5	157.4
1973 I	136.1	171.6	158.8
II	138.9	179.0	164.6
III	144.9	179.0	171.0
IV	150.2	200.6	177.9
1974 I	176.0	218.1	192.1
II	197.1	245.3	221.1
III	207.4	245.0	230.2
IV	215.4	249.6	238.1
1975 I	227.7	267.8	264.3
II	239.9	280.0	276.7
III	248.4	290.1	284.5
IV	256.3	298.1	291.5

Table A.7 (continued)

1963 1st Qrtr = 100	Telegraph and Telephone MLH 363	Other electrical goods MLH 369	Man-made Fibres MLH 411
1963 I	100.0	100.0	100.0
II	100.3	101.1	100.1
III	100.6	101.8	100.4
IV	100.9	103.0	100.6
1964 I	102.6	105.6	100.1
II	103.7	108.0	99.9
III	104.6	111.1	100.3
IV	107.0	115.4	100.3
1965 I	108.4	117.2	100.6
II	109.4	115.6	100.5
III	109.6	114.6	100.5
IV	111.7	117.4	100.7
1966 I	116.3	121.6	101.0
II	122.1	125.4	101.6
III	120.4	122.9	101.6
IV	118.1	120.1	101.2
1967 I	117.0	118.8	100.6
II	113.7	115.8	100.4
III	114.7	116.8	101.0
IV	121.1	123.5	102.6
1968 I	130.3	133.2	104.8
II	125.9	128.8	105.6
III	124.4	128.2	106.0
IV	125.7	129.4	106.0
1969 I	128.7	132.9	105.6
II	132.1	137.0	106.5
III	135.6	142.1	107.1
IV	137.9	145.1	107.6
1970 I	141.1	149.5	109.2
II	143.1	151.6	110.4
III	141.0	149.8	112.8
IV	140.3	143.5	113.8
1971 I	141.9	151.8	116.4
II	145.2	156.3	118.0
III	145.8	157.2	118.6
IV	145.8	155.7	118.5
1972 I	149.0	159.0	118.0
II	154.2	162.4	119.8
III	155.9	164.8	121.2
IV	157.3	167.6	122.5
1973 I	160.6	172.6	123.3
II	165.7	181.0	123.8
III	174.3	194.2	128.8
IV	181.5	208.5	132.6
1974 I	195.5	231.5	159.2
II	214.8	257.4	181.6
III	207.6	250.0	199.0
IV	208.7	253.3	209.1

Table A.7 (continued)

1963 I = 100 YEAR	Pottery MLH 462	Bricks etc. MLH 461	Insulated Wires and Cables MLH 362
1963 I	100.0	100.0	100.0
II	100.9	100.7	100.4
III	101.2	100.7	100.5
IV	101.4	100.8	101.1
1964 I	101.9	101.2	103.6
II	102.0	101.3	106.3
III	102.6	101.7	109.1
IV	103.5	102.4	117.7
1965 I	104.6	104.1	119.8
II	105.1	104.5	122.7
III	105.4	104.7	123.6
IV	105.8	105.0	131.2
1966 I	106.9	105.5	146.2
II	108.1	108.1	167.9
III	108.1	108.5	153.8
IV	107.3	108.4	149.9
1967 I	107.0	108.3	143.8
II	106.7	108.1	130.9
III	108.3	110.4	132.3
IV	110.8	112.1	157.0
1968 I	114.0	113.6	190.6
II	113.8	113.7	161.9
III	113.4	113.5	155.8
IV	113.5	113.9	159.9
1969 I	115.0	115.0	175.0
II	115.6	116.4	187.8
III	116.5	116.9	199.6
IV	117.6	117.7	206.9
1970 I	119.3	120.2	214.6
II	121.3	121.8	213.2
III	123.4	124.0	191.6
IV	125.2	128.1	177.0
1971 I	128.7	132.7	177.3
II	131.8	137.5	187.5
III	133.5	138.9	182.2
IV	134.0	139.6	175.7
1972 I	136.7	142.9	181.4
II	138.4	146.7	182.3
III	140.4	148.3	184.1
IV	142.4	149.8	187.1
1973 I	143.6	150.3	205.8
II	146.8	151.6	228.8
III	151.9	155.9	266.6
IV	157.4	159.6	289.3
1974 I	174.3	185.7	322.5
II	191.1	214.6	364.0
III	197.7	219.6	287.3
IV	209.3	235.4	262.0

Table A.7 (continued)

1963 (1st qrtr) = 100	Domestic Electrical Appliances MLH 368	Made-up textiles and handkerchiefs MLH 422/1	Woollen and Worsted MLH 414
1963 I	100.0	100.0	100.0
II	100.2	100.3	102.4
III	100.4	100.5	103.6
IV	100.8	101.7	109.6
1964 I	102.1	102.9	111.2
II	102.9	104.1	105.9
III	103.5	105.2	102.9
IV	105.1	106.2	98.8
1965 I	106.1	107.1	96.4
II	106.9	107.4	96.4
III	107.1	108.1	98.9
IV	108.3	108.9	100.3
1966 I	111.1	108.8	99.7
II	114.9	109.2	100.6
III	113.8	109.5	98.0
IV	112.6	108.8	95.0
1967 I	111.8	107.9	93.8
II	110.0	107.2	94.2
III	110.7	106.8	89.6
IV	115.0	108.8	87.5
1968 I	121.5	114.7	91.6
II	119.1	115.3	94.3
III	118.3	116.2	94.6
IV	119.1	118.1	97.3
1969 I	121.9	119.4	95.3
II	124.5	121.2	96.8
III	128.0	121.9	96.1
IV	130.3	123.0	93.6
1970 I	135.0	125.0	92.7
II	137.9	128.4	93.7
III	137.7	131.3	92.2
IV	139.1	132.9	89.5
1971 I	141.6	134.5	90.2
II	145.8	136.8	93.4
III	147.0	140.3	93.8
IV	147.0	141.7	92.8
1972 I	148.6	143.1	101.0
II	152.0	145.9	108.5
III	153.9	150.1	122.8
IV	156.2	153.4	157.3
1973 I	158.6	156.1	198.4
II	165.1	163.2	199.7
III	173.6	181.3	208.8
IV	182.0	202.7	207.5
1974 I	198.5	226.8	207.0
II	223.8	238.9	199.2
III	226.1	247.4	187.0
IV	231.0	247.2	171.9

Appendix (continued)

Data: Sources and Methods

Some, but not all of the data which was used in this thesis is available from official published and unpublished sources. Where this is the case we shall only report the data sources, and where appropriate, describe the methods used in adapting or transforming it for the purpose at hand. In this way we also circumvent the disclosure restrictions which applied to a number of price series supplied by the Department of Industry on a confidential basis. These series cannot, in any event, be reported here.

Where the data used was previously unavailable and was generated from primary sources, it will be reported in this appendix.

WHOLESALE PRICE INDEX Published in Trade and Industry (formerly Board of Trade Journal), London: H.M.S.O., and available monthly. The output price indicators cover a range of industrial products defined at MLH level or below. A number of required price indices are subject to disclosure restrictions and are therefore not published. The Department of Industry released this information on a confidential basis and consequently these indicators will not be included in this appendix.

INDEX OF EMPLOYMENT This index was constructed from monthly data of employees in employment by broad (SIC-order) industry groups. For the years 1963 to 1968 the source was British Labour Statistics, Historical Abstract (1971) London: H.M.S.O. Data for subsequent years is published in the Department of Employment Gazette, London: H.M.S.O.

INDEX OF AVERAGE EARNINGS Published in British Labour Statistics, Historical Abstract for the years 1963 to 1968. The index is given for broad (SIC-order) industry groups on a monthly basis. The same index, for the years 1969 to 1974 inclusive, was obtained from the Department of Employment Gazette.

INDEX OF INDUSTRIAL PRODUCTION Compiled by the Department of Industry, this index is available monthly on an SIC-order industrial breakdown, and is published in Trade and Industry. The index is also published in the Monthly Digest of Statistics, London: H.M.S.O.

PRODUCTIVITY TREND REGRESSIONS

As outlined in chapter 5, the quarterly productivity trend was obtained by regressing the logarithm of output per man, in index number form, on time. The estimating equation was as follows:

$$\log (Q/N)_{it} = A + \hat{b}_i t$$

where Q is the index of industrial production, N is the employment index, t is time and $\hat{b}_i$ is the estimated quarterly productivity trend. The values of $\hat{b}_i$ obtained from these regressions for each broad industry group are reported below:

Industry	$\hat{b}_i$
Chemical and Allied	0.0141 (47.3675)
Textile	0.0134 (30.7942)
Engineering	0.0066 (17.0456
Timber and furniture	0.0047 (6.3995)
Bricks etc.	0.0085 (14.2652)
Paper and Printing	0.0054 (11.8470)

Note: Figures in brackets are t-statistics.

PRICE INDEX OF MATERIALS AND FUEL

This data was previously unavailable at MLH level of aggregation and was generated with the help of the Department of Industry Economics and Statistics Division.

The "weighting pattern", that is, the breakdown of material inputs purchased by industries was obtained from table 10 of the Report on the Census of Production 1968, London: H.M.S.O. A weighted average price index of materials and fuel was then calculated using wholesale price indices supplied by the Department of Industry. Given the large number of calculations involved these indicators were generated by computer, using a program written for this purpose by M. Partridge of the University of Warwick. The results of the calculations are reported in table A.7.

BIBLIOGRAPHY

Ackley, G. (1959): "Administered Prices and the Inflationary Process". American Economic Review, vol. 49, pp. 419-461.

Agarwala, R. and Goodson, G. C. (1970): "An Analysis of Consumer Goods' Prices in an Input-Output Framework". Oxford Economic Papers, vol. 22, pp. 57-72.

Alchian, A. A. (1970): "Information Costs, Pricing and Resource Unemployment". In Microeconomic Foundations of Employment and Inflation Theory (E. S. Phelps et. al.), pp. 27-52. New York: W. W. Norton & Company.

Arrow, K. J. (1959): "Toward a Theory of Price Adjustment". In The Allocation of Economic Resources (M. Abramovitz et.al.) pp. 41-51. Stanford: Stanford University Press.

______ (1965): Aspects of the Theory of Risk Bearing. Helsinki: Yrjö Jahnssonin Säätio.

Barro, R. J. (1972): "A Theory of Monopolistic Price Adjustment". Review of Economic Studies, vol. 39, pp. 17-26.

Central Statistical Office (1968): Standard Industrial Classification. London: Her Majesty's Stationery Office.

______ (1970): The Index of Industrial Production and Other Output Measures. London: Her Majesty's Stationery Office.

Chamberlin, E. H. (1962): The Theory of Monopolistic Competition (8th ed.), Cambridge Mass.: Harvard University Press.

Clower, R. W. (1965): "The Keynesian Counter-Revolution : A Theoretical Appraisal". In The Theory of Interest Rates (F. H. Hahn and F. Brechling eds.) pp. 103-125. London: Macmillan.

Coddington, A. (1976): "Keynesian Economics : The Search for First Principles" Journal of Economic Literature, Vol. 14, pp. 1258-1273.

Cowling, K., Cable, J., Kelly, M. and McGuinness, T. (1975): Advertising and Economic Behaviour. London: Macmillan.

Cowling, K. G. and Cubbin, J. S. (1971): "Price, Quality and Advertising Competition : An Econometric Investigation of the United Kingdom Car Market" Economica, vol. 38, pp. 378-394.

______ (1972): "Hedonic Price Indexes for United Kingdom Cars" Economic Journal, vol. 82, pp. 963-978.

Cowling, K. G. and Waterson, M. (1976): "Price-Cost Margins and Market Structure". Economica, vol. 43, pp. 267-274.

Cubbin, J. S. (1974): "A Measure of Apparent Collusion in Oligopoly". Warwick Economic Research Paper No. 49. University of Warwick.

______ (1975): "Quality Change and Pricing Behaviour in the United Kingdom Car Industry 1956-1968". Economica, vol. 42, pp. 43-58.

Diamond, P. A. (1971): "A Model of Price Adjustment" Journal of Economic Theory, vol. 3, pp. 156-168.

Department of Applied Economics, Cambridge (1974): Structural Change in the British Economy 1948-1968 . A Programme for Growth, Volume 12. London: Chapman and Hall.

Depodwin, H. and Selden, R. (1963): "Business Pricing Policies and Inflation. Journal of Political Economy, vol. 81, pp. 116-127.

Dhrymes, P. J. (1964): "On the Theory of the Monopolistic Multiproduct Firm Under Uncertainty". International Economic Review, vol. 5, pp. 239-257.

Dorfman, R. Samuelson, P. A. and Solow, R. M. (1958): Linear Programming and Economic Analysis. New York: McGraw-Hill Book Company.

Eckstein, O. and Fromm, G. (1968): "The Price Equation". American Economic Review, vol. 58, pp. 1159-1183.

Eckstein, O. and Wyss, D. (1972): "Industry Price Equations" In The Econometrics of Price Determination (O. Eckstein, ed.) pp. 133-165. Washington D.C.: Board of Governors of the Federal Reserve System.

Edgeworth, F. Y. (1881): Mathematical Psychics. London: C. Kegan Paul.

Fisher, F. M. (1970): "Quasi-Competitive Price Adjustment by Individual Firms : A Preliminary Paper". Journal of Economic Theory, vol. 2, pp. 195-206.

______ (1972): "On Price Adjustment Without an Auctioneer" Review of Economic Studies, vol. 39, pp. 1-15.

Flemming, J. S. (1976): Inflation. London: Oxford University Press.

Freund, J. E. (1973): Modern Elementary Statistics (4th ed.) Englewood Cliffs: Prentice-Hall.

Friedman, M. (1956): "The Quantity Theory of Money : A Restatement". In Studies in the Quantity Theory of Money (M. Friedman ed.) pp. 3-21. Chicago: Chicago University Press.

Galbraith, J. K. (1957): "Market Structure and Stabilisation Policy". Review of Economics and Statistics, vol. 39, pp. 124-133.

George, K. D. (1975): "A Note on Changes in Industrial Concentration in the United Kingdom". Economic Journal, vol. 85,pp. 124-128.

Glaister, S. (1974): "Advertising Policy and Returns to Scale in Markets where Information is Passed Between Individuals". Economica, vol. 41, pp. 139-155.

Godley, W. A. H. and Nordhaus, W. D. (1972): "Pricing in the Trade Cycle". Economic Journal, vol. 82, pp. 853-882.

Gordon, D. F. and Hynes, A. (1970): "On the Theory of Price Dynamics". In Microeconomic Foundations of Employment and Inflation Theory (E. S. Phelps et. al.) pp. 369-393. New York: W. W. Norton & Company.

Griliches, Z. (1967): "Distributed Lags : A Survey". Econometrica, vol. 35, pp. 16-49.

Hague, D. C. (1971): Pricing in Business. London: George Allen and Unwin.

Hall, R. L. and Hitch, C. J. (1939): "Price Theory and Business Behaviour". Oxford Economic Papers, vol. 2, pp. 12-45.

Hart, P. E., Utton, M. A., and Walshe, G. (1973): Mergers and Concentration in British Industry. London: Cambridge University Press.

Hey, J. (1974): "Price Adjustment in an Atomistic Market". Journal of Economic Theory, vol.8, pp. 483-499.

Hines, A. G. (1971): On the Reappraisal of Keynesian Economics. London: Martin Robertson and Company.

Horowitz, I. (1970): Decision Making and the Theory of the Firm. New York: Holt, Rinehart and Winston.

Hymans, S. H. (1966): "The Price-Taker : Uncertainty, Utility and the Supply Function". International Economic Review, vol. 7, pp. 346-356.

Johnston, J. (1972): Econometric Methods (2nd ed.) New York: McGraw-Hill Book Company.

Keynes, J. M. (1936): The General Theory of Employment, Interest and Money. London: Macmillan.

Kirman, A. P. (1975): "Learning by Firms about Demand Conditions". In Proceedings of the M.R.C. Conference on Adaptive Economics. (R. Day ed.) pp. 137-155. New York: Academic Press.

Lange, O. (1944): Price Flexibility and Full Employment. Bloomington: The Principia Press.

Leijonhufvud, A. (1968): On Keynesian Economics and the Economics of Keynes. New York: Oxford University Press.

Leland, H. E. (1972): "Theory of the Firm Facing Uncertain Demand". American Economic Review. vol. 62, pp. 278-291.

Lustgarten, S. (1975): Administered Inflation : A Reappraisal". Economic Inquiry, vol. 13, pp. 191-206.

Marshall, A. (1920): Principles of Economics (8th ed.) London: Macmillan.

McCall, J. J. (1965): "The Economics of Information and Optimal Stopping Rules" Journal of Business, vol. 38, pp. 300-317.

McCallum, B. T. (1974): "Competitive Price Adjustments : An Empirical Study". American Economic Review. vol. 64, pp. 56-65.

Means, G. C. (1935): Industrial Prices and their Relative Inflexibility. United States Senate Document 13, 74th Congress, 1st Session Washington D.C.

______ (1959): Hearings on Administered Prices, Part 9. Senate Subcommittee on Antitrust and Monopoly, pp. 4745-4760. Washington D.C.

______ (1972): "The Administered Price Thesis Reconfirmed". American Economic Review, vol. 62, pp. 292-306.

Mills, E. S. (1962): Price, Output, and Inventory Policy. New York: John Wiley & Sons.

Monopolies Commission (1973): Parallel Pricing - A Report on the General Effect on the Public Interest of the Practice of Parallel Pricing. Cmnd. 5330. London: Her Majesty's Stationery Office.

Neild, R. R. (1963): Pricing and Employment in the Trade Cycle. London: Cambridge University Press.

Nicholson, M. (1972): Oligopoly and Conflict. Liverpool: Liverpool University Press.

Nordhaus, W. D. (1972): "Recent Developments in Price Dynamics", In The Econometrics of Price Determination. (O. Eckstein ed.) pp. 16-49. Washington D.C.: Board of Governors of the Federal Reserve System.

Panić, M. (1976): "The Inevitable Inflation" Lloyds Bank Review, No. 121 pp. 1-15.

Phelps, E. S. (1970): "The New Microeconomics in Employment and Inflation Theory". In Microeconomic Foundations of Inflation and Employment Theory. (E. S. Phelps et.al.) pp. 1-23. New York: W. W. Norton & Company.

Phlips, L. (1971): Effects of Industrial Concentration : A Cross-Section Analysis for the Common Market". Amsterdam: North-Holland Publishing Company.

Pratt, J. W. (1964): "Risk Aversion in the Small and in the Large" Econometrica, vol. 32, pp. 122-136.

Rothschild, M. (1973): "Models of Market Organisation with Imperfect Information : A Survey". Journal of Political Economy, vol. 81, pp. 1283-1308.

Samuelson, P. A. (1947): Foundations of Economic Analysis. Cambridge, Mass.: Harvard University Press.

Sandmo, A. (1971): "On the Theory of the Competitive Firm under Price Uncertainty". American Economic Review, vol. 61, pp. 65-73.

Scherer, F. M. (1970): Industrial Market Structure and Economic Performance. Chicago: Rand McNally & Company.

Stigler, G. J. (1961): "The Economics of Information" Journal of Political Economy, vol. 6 pp. 213-225.

______ (1962): "Administered Prices and Oligopolistic Inflation". Journal of Business, vol. 35, pp. 1-13.

_____ (1964): "A Theory of Oligopoly" Journal of Political Economy, vol. 72, pp. 44-61.

Stigler, G. J. and Kindahl, J. K. (1970): The Behaviour of Industrial Prices. New York: National Bureau of Economic Research.

Stoneman, P. L. (1976): "Mergers and Concentration". Mimeo, University of Warwick.

Sweezy, P. M. (1939): "Demand under Conditions of Oligopoly" Journal of Political Economy, vol. 47, pp. 568-573.

Tilanus, C. B. (1966): Input-Output Experiments: The Netherlands 1948-1961. Rotterdam: Rotterdam University Press.

Walras, L. (1874): Elements of Pure Economics (trans. W. Jaffe, 1954) London: George Allen & Unwin.

Weiss, L. W. (1966): "Business Pricing Policies and Inflation Reconsidered" Journal of Political Economy, vol. 74, pp. 177-178.

Wiles, P. (1973): "Cost Inflation and the State of Economic Theory". Economic Journal, vol. 83, pp. 377-398.

Williamson, J. and Wood, G. E. (1976): "The British Inflation: Indigenous or Imported?" American Economic Review, vol. 66, pp. 520-531.

Yordon, W. J. (1961): "Industrial Concentration and Price Flexibility in Inflation: Response Rates in Fourteen Industries, 1947-1958". Review of Economics and Statistics, vol. 43, pp. 287-294.